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BEFORE THE PUBLIC UTILITIES COMMISSION OF THE

STATE OF CALIFORNIA

Application of Southern California Edison Company (U 338-E) for Approval of Its 2021-2025 Investment Plan for the Electric Program Investment Charge.	Application 22-10-___

APPLICATION OF SOUTHERN CALIFORNIA EDISON COMPANY (U 338-E) FOR APPROVAL OF ITS 2021-2025 INVESTMENT PLAN FOR THE ELECTRIC PROGRAM INVESTMENT CHARGE

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Dated: **October 3, 2022**

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I.

INTRODUCTION

Southern California Edison Company (SCE) respectfully submits this application requesting approval of its fourth Investment Plan for the Electric Program Investment Charge (EPIC) covering 2021 through 2025, which is attached hereto. In the California Public Utilities Commission's (Commission) Decision (D.)21-11-028, the Commission required that the EPIC program administrators file applications for their investment plans by October 1, 2022.[1] The EPIC program administrators are SCE, Pacific Gas & Electric Company, San Diego Gas & Electric Company, and the California Energy Commission (CEC). SCE files this application in compliance with D.21-11-028, as well as previous Commission EPIC proceeding decisions.[2]

In summary, SCE requests that the Commission:

- Find that SCE's EPIC-4 Application and Plan are in compliance with the requirements of past EPIC decisions.
- Approve SCE's EPIC-4 Plan as reasonable, appropriate and in the interest of electric utility ratepayers.

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1 D.21-11-028, Ordering Paragraph (OP) 8, at p. 57.

2 D.12-05-037; D.13-11-025; D.15-04-020; D.18-10-052; Research Administration Plan (RAP) approval decisions such as D. 20-02-003.

- Authorize SCE to file Tier 3 Advice Letter(s) to request approval to add any additional research topics to their plans, after their plans are approved.[3]
- Render other Findings of Fact, Conclusions of Law, and issuing Orders consistent with the foregoing requests; and
- Provide any other relief as is necessary and proper.

II.
BACKGROUND

The Commission established the EPIC in 2011 and renewed the Program in 2019. On November 21, 2021, the Commission issued its decision authorizing the Utilities to continue to serve as EPIC program administrators, along with the CEC.[4]

The Commission's mission for EPIC is to "invest in innovation to ensure equitable access to safe, affordable, reliable, and environmentally sustainable energy for electricity ratepayers."[5] EPIC's guiding principle is to provide benefits to customers with a focus on safety, reliability, and affordability.[6] The EPIC is composed of three areas: (1) research and development, (2) technology demonstration and deployment, and (3) market facilitation programs for the benefit of the IOUs' ratepayers.[7] However, the IOUs are only allowed to administer technology demonstration and deployment.[8] Approximately 80% of the total EPIC funding is administered by the CEC, with the remaining 20% is administered by the IOUs. Additionally, 0.5% of the budget funds Commission oversight of the EPIC.[9] SCE's EPIC budget for 2021-2025 is $76 million.[10]

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[3] This would be consistent with the previous process for requesting approval to pursue additional projects for investment plans filed at the project level in EPIC-1 through EPIC-3.
[4] D.21-11-028.
[5] D.21-11-028, Appendix A.
[6] *Id.*
[7] D.12-05-037, at OP 1.
[8] *Id.*, at OP 7.
[9] *Id.*, at OP 5.
[10] D.21-11-028, Appendix B, at B-3.

SCE's fourth EPIC plan covers the period of 2021 through 2025. The Commission instructed the IOUs to file investment plan applications for EPIC 4 on October 1, 2022.[11] The Commission further directed all Administrators to file EPIC 4 investments plans at the Strategic Initiative level. Strategic Initiatives are defined as the strategies EPIC Administrators employ to meet their high-level Strategic Objectives. EPIC Administrators shall propose funding levels for the Strategic Initiatives and specify how these initiatives will be operationalized, including the proposed activities.[12]

At least twice per year, during the development of the respective investment plans and during the execution of those plans, the EPIC administrators are required to consult with stakeholders. These stakeholders include representatives of the legislature, government agencies, utilities, the California Independent System Operator, consumer groups, environmental organizations, agricultural organizations, academics, the business community, the energy efficiency community, the clean energy industry, and other industry associations.[13]

III.
SUMMARY OF SCE'S INVESTMENT PLAN

SCE's EPIC 4 Investment Plan for the 2021-2025 program cycle represents a collaborative effort between SCE and the other program administrators, incorporates the input of stakeholders and addresses the requirements of D.21-11-028, as well as previous Commission EPIC proceeding decisions.

SCE's EPIC 4 Investment Plan consists of the following sections:

I. Executive Summary

II. Introduction and Background

III. Impact of IOU's EPIC Program

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[11] D.21-11-028, OP 7, at pp. 56-57. Because October 1, 2022, falls on a Saturday, SCE's application is timely filed on October 3, 2022.

[12] D.21-11-028, OP 8, at p. 57.

[13] *Id*., at OP 15.

IV. Summary of Stakeholder Input

IV. Overview of Investment Plan Framework and Budget Allocation

VI-VIII. SCE's EPIC Investment Plan (Strategic Objectives; Strategic Initiatives; Research Topics)

IX. Program Administration

X. Conclusion

The Executive Summary provides an overview of SCE's EPIC 4 Investment Plan and program administration. The Introduction and Background section describes the regulatory background of EPIC. The next section, Impact of SCE's EPIC Program, describes the benefits SCE's demonstration projects provides to customers with a focus on safety, reliability and affordability. The Summary of Stakeholder input section describes SCE's extensive collaboration with stakeholders. The joint Utilities held four public engagements, two of which targeted Disadvantaged Communities (DACs). This section also summarizes the comments submitted by interested parties.

The Utilities have coordinated their respective EPIC 4 Plans to use the same structure as the CEC's EPIC 4 Investment Plans that apply to the technology demonstration area. Furthermore, IOU administrators have followed the Commission's guidance to file at the Initiative level. Thus, SCE's EPIC 4 Investment Plan is composed of three areas of strategic investment, called Strategic Objectives: (1) Create a More Nimble Grid to Maintain Reliability as California Transitions to 100 Percent Clean Energy, (2) Increase the Value Proposition of Distributed Energy Resources to Customers and the Grid, and (3) Guide California's Transition to a Zero-Carbon Energy System that is Climate-Resilient and Meets Environmental Goals. Within these Strategic Objectives, SCE has proposed six Strategic Initiatives, which are specific opportunities and/or challenges. Details of how these opportunities and/or challenges will be operationalized are called Research Topics and SCE has proposed 15 Research Topics.

The Program Administration section explains SCE's approach to program outreach efforts, portfolio management, knowledge sharing and lessons learned, as well as benefits metrics and evaluation. Equity is embedded throughout SCE's approach to administering the EPIC Program.

In compliance with D.21-11-028, SCE includes in its Plan the following appendices:

- Appendix A: Benefits Impacts Report of its EPIC projects.
- Appendix B: List of Acronyms and Abbreviations.
- Appendix C: Stakeholder Engagement, which provides high-level summaries of the public workshops.
- Appendix D: List of approved energy efficiency and demand response portfolios, detailing each project's purpose, funding, deliverables and progress to date.[14]

IV.
PROCEDURAL REQUIREMENTS

A. Statutory Authority (Rule 2.1)

This application is made pursuant to D.21-11-028, the Public Utilities Code, the Commission's Rules of Practice and Procedure, and prior decisions, orders, resolutions of the Commission.

B. Legal Name and Principal Place of Business (Rule 2.1(a))

SCE's full legal name is Southern California Edison Company. SCE is a public utility organized and existing under the laws of the State of California. The location of SCE's principal place of business is 2244 Walnut Grove Avenue, Rosemead, California, 91770. SCE is a wholly-owned subsidiary of Edison International, a public utility holding company incorporated in the State of Delaware.

C. Correspondence (Rule 2.1(b))

Correspondence or communication regarding this application should be addressed to:

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[14] D.13-11-025, p. 66.

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D. Proposed Categorization (Rule 2.1(c))

SCE proposes to characterize this proceeding as quasi-legislative, as defined in Rule 1.3(d).

E. Need for Hearing, Issues to Be Considered, and Proposed Schedule (Rule 2.1(c))

The need for hearings and the issues to be considered depend upon the degree to which other parties might contest SCE's application. Assuming other parties contest SCE's application, SCE recommends the Commission hold workshops to seek public comment on SCE's and the other administrators' investment plans. The workshops held during the investment plan development process facilitated stakeholder input and efficiently addressed the Utility EPIC administrators' investment plans. The same benefits would result from workshops held during the application process. In addition, the Commission has recognized the utility of workshops for the EPIC program by requiring the administrators to continue consulting with stakeholders at least twice per year.

SCE proposes the following schedule:

Event	Proposed Date
Application Filed	October 3, 2022
Protests and Responses	November 7, 2022
Reply to Protests and Responses	November 14, 2022
Workshops	December 2022
Opening Briefs	January 11, 2023
Reply Briefs	February 1, 2023
ALJ Proposed Decision	March 6, 2023
Comments on Proposed Decision	March 20, 2023
Reply Comments	March 27, 2023
Commission Decision	April 2023

F. Organization and Qualification to Transact Business (Rule 2.2)

A copy of SCE's Certificate of Restated Articles of Incorporation, effective on March 2, 2006, and presently in effect, certified by the California Secretary of State, was filed with the Commission on March 14, 2006, in connection with A.06-03-020, and is incorporated herein by this reference.

A copy of SCE's Certificate of Determination of Preferences of the Series D Preference Stock filed with the California Secretary of State on March 7, 2011, and presently in effect, certified by the California Secretary of State, was filed with the Commission on April 1, 2011, in connection with Application No. 11-04-001, and is incorporated herein by this reference.

A copy of SCE's Certificate of Determination of Preferences of the Series E Preference Stock filed with the California Secretary of State on January 12, 2012, and a copy of SCE's Certificate of Increase in Authorized Shares of the Series E Preference Stock filed with the California Secretary of State on January 31, 2012, and presently in effect, certified by the California Secretary of State, were filed with the Commission on March 5, 2012, in connection with Application No. 12-03-004, and is incorporated herein by this reference.

A copy of SCE's Certificate of Determination of Preferences of the Series F Preference Stock filed with the California Secretary of State on May 14, 2012, and presently in effect, certified by the California Secretary of State, was filed with the Commission on June 29, 2012, in connection with Application No. 12-06-017, and is incorporated herein by this reference.

A copy of SCE's Certificate of Determination of Preferences of the Series G Preference Stock filed with the California Secretary of State on January 24, 2013, and presently in effect, certified by the California Secretary of State, was filed with the Commission on January 31, 2013, in connection with Application No. 13-01-016, and is incorporated herein by this reference.

A copy of SCE's Certificate of Determination of Preferences of the Series H Preference Stock filed with the California Secretary of State on February 28, 2014, and presently in effect, certified by the California Secretary of State, was filed with the Commission on March 24, 2014, in connection with Application No. 14-03-013, and is incorporated herein by this reference.

A copy of SCE's Certificate of Determination of Preferences of the Series J Preference Stock filed with the California Secretary of State on August 19, 2015, and presently in effect, certified by the California Secretary of State was filed with the Commission on October 2, 2015, in connection with Application No. 15-10-001, and is incorporated herein by this reference.

A copy of SCE's Certificate of Determination of Preferences of the Series K Preference Stock filed with the California Secretary of State on March 2, 2016, and presently in effect, certified by the California Secretary of State, was filed with the Commission on April 1, 2016, in connection with Application No. 16-04-001, and is incorporated herein by this reference.

A copy of SCE's Certificate of Determination of Preferences of the Series L Preference Stock filed with the California Secretary of State on June 20, 2017, and presently in effect, certified by the California Secretary of State, was filed with the Commission on June 30, 2017, in connection with Application No. 17-06-030, and is incorporated herein by this reference.

Copies of SCE's latest Annual Report to Shareholders and Edison International's latest proxy statement sent to its stockholders has been filed with the Commission with a letter of transmittal dated March 18, 2022, pursuant to General Order Nos. 65-A and 104-A of the Commission.

G. <u>Service List</u>

As directed by D.12-05-037, Ordering Paragraph 11, SCE is serving this application on the services lists for this rulemaking (R.19-10-005), SCE's EPIC 3 Investment Plan Application (A.17-04-028), the joint Utilities EPIC Research Administration Plan (RAP) Application (A.19-04-026) and SCE's most recent general rate case (A.19-08-013).

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Respectfully submitted,

CLAIRE TORCHIA
GLORIA M. ING

/s/ Gloria M. Ing

By: Gloria M. Ing

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SOUTHERN CALIFORNIA EDISON COMPANY

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October 3, 2022

VERIFICATION

I am a Senior Vice President of Southern California Edison Company and am authorized to make this verification on its behalf. I am informed and believe that the matters stated in the foregoing pleading are true.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on September 28, 2022, at Pomona, California

/s/ Erik Takayesu
Erik Takayesu
Senior Vice President
Asset Strategy and Planning
Southern California Edison Company

Attachment A

SCE EPIC 4 Investment Plan

Southern California Edison

EPIC 4 Investment Plan

Table of Contents

I. Executive Summary

The California Public Utilities Commission (Commission) established the Electric Program Investment Charge (EPIC) in 2011 and renewed the Program in 2019. The Commission's mission for EPIC is to "invest in innovation to ensure equitable access to safe, affordable, reliable, and environmentally sustainable energy for electricity ratepayers."[1] The EPIC guiding principle is to provide benefits to customers with a focus on safety, reliability, and affordability.[2] On November 21, 2021, the Commission issued Decision (D.) 21-11-028 authorizing the Utilities to continue to be EPIC program administrators, along with the California Energy Commission (CEC), for EPIC 4. The Commission further determined that the CEC would continue to receive 80 percent of the budget with the Utilities sharing the remaining 20 percent of the budget. SCE's authorized EPIC 4 budget is $76,035,000.[3] The Commission instructed SCE, along with PG&E and SDG&E to each file an EPIC 4 Investment Plan Application covering 2021-2025 on October 1, 2022.

SCE's past EPIC projects have provided value to utility customers by facilitating and accelerating integration of new technologies onto the electric grid, helping to advance the safety, affordability, reliability and delivery of clean energy to customers. EPIC projects are critical toward helping California achieve its energy and environmental policy goals and support key Commission proceedings.

SCE's EPIC 4 Investment Plan continues to drive innovation to support California's progress toward a clean energy future. SCE's EPIC 4 Plan focuses on advancements toward carbon-neutrality, expanding the potential benefits of distributed energy resources (DERs) and creating a grid more resilient to impacts from climate change and other emerging threats, such as cyber-attacks.

During the development of the Utilities' EPIC 4 Investment Plans, extensive stakeholder engagement was conducted. The joint Utilities held four public workshops, two of which were targeted to Disadvantaged and vulnerable communities. Additionally, the Utilities provided a joint presentation to the Disadvantaged Communities Advisory Group (DACAG). The Utilities jointly held numerous discussions to mitigate duplication among the plans, while complementing the CEC's EPIC 4 Plan and relevant Commission proceedings.

SCE has incorporated feedback from the DACAG to better embed equity by applying the principles of the DACAG's equity framework to SCE's EPIC 4 Plan. SCE has included an equity matrix to provide an overview of its proposed topics and the anticipated direct and indirect equity impacts.

SCE's EPIC 4 Investment Plan is composed of three areas of strategic investment, called Strategic Objectives. Within these Strategic Objectives, SCE has proposed six Strategic Initiatives, which are specific opportunities and/or challenges. Details of how these opportunities and/or challenges will be operationalized are called Research Topics and SCE has proposed 15 topics. Each Strategic Objective, Strategic Initiative and Research Topic is described within SCE's EPIC 4 Plan.

[1] D.21-11-028, Appendix A.
[2] *Id.*
[3] Includes administrative and project budgets, as well as CPUC oversight cost.

Strategic Objective A: Create a More Nimble Grid to Maintain Reliability as California Transitions to 100 Percent Clean Energy

As California transitions toward its goal of 100 percent clean electricity by 2045, the grid will need to overcome significant challenges to its design, operation and maintenance. SCE's EPIC 4 demonstrations help to enable a more flexible grid by furthering integration of DERs. In support of enabling effective integration of these energy resources, SCE has identified two Strategic Initiatives:

- Strategic Initiative, T&D Foundational Technologies: are critical to enabling a more flexible grid by evaluating and demonstrating pre-commercial equipment and applications to increase grid monitoring, protection and control.
- Strategic Initiative, T&D Situational Capabilities: examines how to increase utilization by increasing throughput on a given circuit, as well as increasing grid operations flexibility.

Strategic Objective B: Increase the Value Proposition of Distributed Energy Resources to Customers and the Grid

DERs are critical to California achieving a clean energy future. DERs are increasing and have many potential benefits to grid operators and customers. However, there are operational challenges to integrating and optimizing DERs on the grid. The capabilities of DERs to deliver grid services needs to be demonstrated to achieve potential benefits.

- Strategic Initiative, Energy Management Foundational Technologies: enhances the reliable operation of the electric grid, even when considering a diverse mix of resources from community to community or region to region
- Strategic Initiative, Energy Management Situational Capabilities: aims to grow and enhance utility energy management capabilities by leveraging DERs through advancements in energy storage and grid controls.

Strategic Objective C: Guide California's Transition to a Zero-Carbon Energy System that is Climate-Resilient and Meets Environmental Goals

To achieve a climate-resilient and reliable grid that can be flexible and adaptable to our changing climate and increasing environmental hazards (e.g., extreme heat and wildfire threat), new methods of system analysis will need to be developed. Utilities will need to perform a more integrated analysis of the transmission and distribution (T&D) system as one integrated system, taking into account how climate and energy usage will continue to change over time, both in planning and in operations.

- Strategic Initiative, Vulnerabilities, Threats, and Hazard Reduction: assesses environmental hazards, as well as new approaches to grid hardening helps mitigate the impacts of these environmental threats
- Strategic Initiative, Digital Transformation: evaluates integration of emerging technologies onto the grid, digitalizing data and processes is critical for greater grid operator awareness to optimize these assets and mitigate threats from climate change.

Details of how these opportunities and/or challenges will be operationalized are called Research Topics and SCE has proposed 15 topics. Each Strategic Objective, Strategic Initiative and Research Topic is described in more detail within SCE's EPIC 4 Plan.

II. Introduction and Background

Regulatory Background

The California Public Utilities Commission (Commission) established the Electric Program Investment Charge (EPIC) on December 15, 2011.[4] The purpose of EPIC is to "provide public interest investments in applied research and development, technology demonstration and deployment, market support, and market facilitation, of clean energy technologies and approaches for the benefit of electricity ratepayers of Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), and Southern California Edison (SCE), the three large investor-owned utilities (IOUs)."[5]

The Commission initiated Rulemaking (R.) 19-10-005 on October 10, 2019 to examine whether to renew EPIC funding, which was set to sunset on December 31, 2020. In phase 1 of the Rulemaking, on September 2, 2020, the Commission issued Decision (D.) 20-08-042, "to renew EPIC because the program benefits electric IOU ratepayers and California in addressing wildfire risk, meeting climate goals, creating job growth, and other benefits based on quantifiable results from the previous EPIC programs."[6] The Commission renewed funding for 10 years, through December 31, 2030, and authorized two five-year investment plan cycles (referred to respectively, as EPIC 4 and EPIC 5).[7] The Commission also authorized the California Energy Commission (CEC) to continue being an EPIC Administrator, with an annual budget of $147.26 million for the EPIC 4 investment cycle (2021-2025).[8] The CEC received Commission approvals of its interim EPIC 4 Investment Plan on July, 15, 2021[9] and its EPIC 4 Investment Plan on June 2, 2022.[10]

On November 21, 2021, during phase 2 of the Commission's EPIC Rulemaking, the Commission issued D.21-11-028 authorizing PG&E, SCE and SDG&E to continue in their role as EPIC Administrators, along with the CEC.[11] The Commission authorized SCE an annual budget of $15.131 million for the EPIC 4 cycle.[12] The Commission instructed the IOUs to file investment plan applications for EPIC 4 on October 1, 2022.[13] The Commission further directed all Administrators to file EPIC 4 investments plans at the Strategic Initiative level. Strategic Initiatives are defined as the strategies EPIC Administrators employ to meet their high-level Strategic Objectives. EPIC Administrators shall propose funding levels for the Strategic Initiatives and specify how these initiatives will be operationalized, including the proposed activities.[14]

This Decision also revised EPIC's Guiding Principles definition of ratepayer benefits to include improving safety, increasing reliability, increasing affordability, improving environmental sustainability, and

[4] Decision (D.)11-12-035.
[5] D.12-05-037 at p. 2.
[6] D.20-08-042 at p. 17.
[7] D.20-08-042 Ordering Paragraph (OP) 1 at p. 32.
[8] D.20-08-042.
[9] D.21-07-006.
[10] D.22-06-004 OP1 at p. 46.
[11] D.21-11-028, OP 1, at p. 55.
[12] D.21-11-028, OP 3, at pp. 55-56.
[13] D.21-11-028, OP 7, at pp. 56-57.
[14] D.21-11-028, OP 8, at p. 57.

improving equity. These benefits must accrue to ratepayers and relate to the electric grid.[15] Ratepayer benefits are discussed within each respective Research Topic of SCE's EPIC 4 Investment Plan.

III. Impact of SCE's EPIC Program

SCE's EPIC program has provided value to our customers by providing a means to test, evaluate and integrate pre-commercial or early commercial technologies to advance the electric grid. All 38 of SCE's projects from EPIC 1-3 have provided customer benefits, which prior to D.21-11-028 were defined as increased safety, improved reliability, reduced costs, and complementary benefits. These projects provided additional value by supporting CPUC proceedings, influencing market products, and informing industry standards and SCE's GRC capital requests. EPIC provides a crucial path to market for promising technologies. EPIC also provides a means for examining novel approaches to identifying and examining new cyber threats and their impacts to the grid.

The Commission directed the Utilities to "file a report documenting their success to date of the EPIC projects under its administration, using the metrics they are ordered to create in Ordering Paragraph 12, and in working with this Commission's Energy Division staff."[16] The Utilities worked with the CEC and Commission staff to create a uniform approach for assessing the benefits of EPIC projects. As directed by the Commission, SCE has attached its Benefits Impact Report to its EPIC 4 Investment Plan Application as Appendix A.

Examples of the impact of SCE's EPIC projects include:

- SCE's EPIC Integrated Grid Project (EPIC 1 and 2) provided a substantial number of requirements into SCE'S new Grid Management System, which is being implemented to replace the Distribution Management System.[17] A subproject of the Integrated Grid Project, the Electric Access System Enhancement (EASE) project, informed how a distribution system operator can manage a transactive energy marketplace for large penetrations of aggregated DERs to provide day-ahead energy services for the distribution system. It was selected as the 2022 Smart Electric Power Alliance Utility Transformation Project of the Year.[18]
- Distribution Automation projects (EPIC 1 and 2) have informed technical requirements, specifications, and product recommendations for much of the operational technology (OT) aspects of SCE's Grid Modernization program, including for remote switches, reclosers and fault indicators.[19]
- Substation Automation projects (EPIC 1 and 2) have informed technical requirements for digitizing Protection, Automation, and Control of modern electrical substations. This work has led to more future leaning projects including the virtualization of protection relaying in EPIC 3.[20]

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[15] D.21-11-028, OP 2, at p. 55.
[16] D.21-11-028, OP 13, at p. 58.
[17] Benefits Impacts Report, Appendix A at p. A-1.
[18] https://sepapower.org/knowledge/sepa-announces-2022-utility-transformation-award-winners/.
[19] Benefits Impacts Report, Appendix A at p. A-1.
[20] Benefits Impacts Report, Appendix A at p. 1.

- DER Dynamics Integration Demonstration (EPIC 3) has informed our understanding of the power system dynamics created by high DER penetration and how Distribution relaying protection systems will need to evolve or be modified as a result.[21]

Examples of additional benefits anticipated from ongoing and future demonstration projects include:

- Technologies from Next-Generation Distribution Automation informed the development of the Commission's Distributed Resources Plan (DRP) Proceeding Track 3 Sub-Track 2 Grid Modernization classification tables and definitions.[22]
- The DC Fast Charging Demonstration methodology for monitoring power quality informed Society of Automotive Engineering (SAE) J2894/1: Power Quality Requirements for Plug-in Electric Vehicle Chargers. SCE co-chaired both SAE J 2894/1 and J2894/2 Power Quality Test Procedures for Plug-in Electric Vehicle Chargers.[23]

SCE's proposed EPIC 4 Portfolio Budget will help California achieve energy and environmental policy goals, such as 100 Percent Clean Energy by 2045,[24] 100 Percent Zero-Emission Vehicles by 2035,[25] Climate Change 2022 Scoping Plan.[26] Additionally, SCE's proposed budget for EPIC 4 supports the Commission's key proceedings, such as Integrated Resources Plans,[27] Development of Rates and Infrastructure for Vehicle Electrification (DRIVE),[28] and Climate Adaptation,[29] by informing these proceedings with data from demonstrations.

These important California energy and environmental policy goals and Commission proceedings are represented as Strategic Objectives. SCE provides Illustrative examples of its Strategic Objectives and how key policies are supported through potential EPIC 4 advancements by addressing associated barriers is provided below:

1) *Strategic Objective A:* Create a More Nimble Grid to Maintain Reliability as California Transitions to 100 Percent Clean Energy
    a. *Energy Policy Goal:* SB 100: 100 Percent Clean Energy by 2045
    b. *Commission Proceeding:* IRP

    The State has a goal of 100 percent of electric retail sales to customers must be from renewable and zero-carbon energy resources by 2045, and an important component of the Utilities' IRP proceeding is enabling the transition to delivery of clean energy. SCE's EPIC 4 Strategic Objective A supports achievement of the State's energy policy goal and the Commission's IRP

[21] Benefits Impacts Report, Appendix A at p. A-1.
[22] Benefits Impacts Report, Appendix A at p. A-4.
[23] Benefits Impacts Report, Appendix A at p. A-4.
[24] SB 100, De León, Chapter 312, Statutes of 2018.
[25] Executive Order (EO) N-79-20, 2020.
[26] AB 32 requires the California Air Resources Board to develop a Scoping Plan that describes the approach California will take to reduce GHGs. The Draft 2022 Scoping Plan assesses progress toward the statutory 2030 target, while laying out a path to achieving carbon neutrality no later than 2045.
[27] R.16-02-007.
[28] R.18-12-006.
[29] R.18-04-019.

proceedings by continuing innovation to enable reliable, resilient, renewable and affordable clean energy. SCE provides the following examples of advancements, which include:

- Identify and evaluate technologies and strategies for cost-effectively increasing capacity to move vast quantities of renewable energy across the grid.
- Enhance monitoring capabilities to ensure grid stability is maintained as an inverter based resource (IBR) dominated grid grows increasingly complex and dynamic.
- Advance planning tools and technologies to accelerate safe interconnection of new renewable generation and energy storage resources.
- Determine how to evolve fault isolation / relaying ("protection") systems from static to adaptive architectures to ensure worker and public safety is maintained and electrical system equipment is preserved, as grid conditions change.

2) *Strategic Objective B:* Increase the Value Proposition of Distributed Energy Resources to Customers and the Grid
   a. *Energy Policy Goal:* 100 Percent Zero-Emission Vehicles by 2035
   b. *Commission Proceeding:* DRIVE

California has a statewide target for 100 percent of passenger vehicles, off-road and drayage operations sales to be zero emission by 2035, and where feasible all medium and heavy-duty vehicles to be zero-emission by 2045. A key component of the Commission's DRIVE proceeding is helping the State achieve this electrification of transportation. SCE's EPIC 4 Strategic Objective B supports these goals and provides example advancements to reduce policy and technical barriers, which include:

- Electric vehicles (EVs) managed as DERs, whether in managed charging or inverter-based resource operations, can be shown to effectively act in concert with grid needs while continuing to support customer owners, providing reliable services while managing costs.
- Integrated controls, including elevated cybersecurity standards and posture, to ensure EV resources are at the time and location with availability to make them useful for grid purposes.
- Autonomous EV operation and charging systems and grid support functions working to minimize the cost of the transition to full electrification while ensuring grid reliability standards are maintained.

3) *Strategic Objective C:* Guide California's Transition to a Zero-Carbon Energy System that is Climate-Resilient and Meets Environmental Goals
   a. *Energy Policy Goal:* AB: 32, Climate Change 2022 Scoping Plan
   b. *Commission Proceeding:* Climate Adaptation

The State has a goal to eliminate greenhouse gas emissions and become carbon neutral by 2045. Furthermore, an important aspect of the Commission's Climate Adaptation proceeding is mitigating environmental impacts from climate change and other emerging threats, such as cyberattacks. SCE's Strategic Objective C supports the State's energy policy goal and the Commission's Climate Adaptation proceeding by reducing policy and technical barriers and provides the following example advancements:

- Identify and demonstrate mitigations to extreme events caused by climate change.
- Evaluate and document enhancements to utility planning practices to account for climate change and other emerging threats.
- Coordinate implementation of the digital transformation to be able to address environmental and cybersecurity events.
- Demonstrate the utilization of modern technology to enhance the safety of both the public and utility personnel.

IV. Summary of stakeholder engagement in investment planning process

Internal Engagement

SCE conducted wide-ranging internal ideation for its EPIC 4 Investment Plan. To develop a coordinated EPIC 4 Investment Plan with the CEC, SCE initiated its planning by developing a matrix that mapped the CEC's EPIC 4 Investment Plan strategic objectives to capabilities identified in SCE's vision for the future of the electric grid, called Reimagining the Grid. SCE then aligned the CEC's EPIC 4 initiatives to capabilities within Reimaging the Grid[30] and SCE's 2022 Climate Adaptation Vulnerability Assessment (CAVA).[31] SCE collaborated extensively across the enterprise (including Strategy, Customer Service, Transportation Electrification, Information Technology, and Transmission & Distribution) to identify and resolve gaps in SCE's proposed EPIC 4 topics.

External Engagement

The Utilities conducted extensive stakeholder engagement during planning for EPIC 4, including four public workshops. These workshops included an initial overview of each Utility's proposed initiatives, presented with panel-led discussions by the Electric Power Research Institute (EPRI)—an independent, non-profit organization recognized as a leader in conducting electric utility industry research and development. The second workshop provided an overview of each Utility's topics, presented thematically by Strategic Initiative. Additionally, the Utilities held two targeted public workshops to discuss how disadvantaged communities (DACs) can engage in each of the Utilities' EPIC 4 Investment Plans. These public workshops were well-attended with a broad spectrum of participants, including academia, environmental, customer advocates and community-based organizations.

Comments from stakeholders focused on general programmatic information as well as technology gaps and priorities. An energy services company from the vendor community at the August 29, 2022 Public Workshop raised utility-owned communications platform for DER owners as a potential technology gap. After the Workshop, SCE acknowledged utility-owned communications platform for DER owners as a technology gap and has incorporated this feedback into the EPIC 4 Investment Plan. SCE recognizes the importance of communications to further optimize DERs on the grid and has identified the Energy Management Foundational Technologies as the most appropriate initiative. SCE plans to cover different

[30] https://www.edison.com/home/our-perspective/reimagining-the-grid.html.
[31] https://www.sce.com/about-us/environment/climate-adaptation.

aspects of DER communications under the Localized and Edge Control and Customer Load Flexibility Research Topics.

Table 1 summarizes the names and dates of each public workshop.

Table 1: EPIC 4 Public Workshops

EPIC 4 Public Event Title	Date
Public DAC Workshop	June 21, 2022
Public Workshop	June 30, 2022
2nd Public DAC Workshop	August 26, 2022
2nd Public Workshop	August 29, 2022

Presentations from these workshops can be found on each of the Utilities' respective EPIC webpages.[32] For additional details, please see Appendix C Stakeholder Engagement, which provides high-level workshop summaries.

The Utilities also coordinated their planning to help prevent duplication among the Utilities' proposed EPIC 4 topics and to complement related activities across the other Utilities and CEC, while also supporting related CPUC proceedings.

The Utilities also reached out to the Disadvantaged Communities Advisory Group (DACAG) by announcing the joint Utilities DAC Workshops at the DACAG meetings. On August 19, 2022, the joint Utilities presented their EPIC 4 Plans and explained how the initiatives would benefit DACs[33] and under-resourced communities. The joint Utilities incorporated feedback from the DACAG into their 2nd DAC Workshop presentation to expand on how DACs and under-resourced communities can help provide feedback and shape EPIC 4 projects at project public workshops, following Commission approval of the Utilities' EPIC 4 Investment Plans.

SCE has also incorporated feedback from the DACAG to apply their Equity Framework to our EPIC 4 Investment Plan. The DACAG Equity Framework outlines the following five key equity principles:

1. Health and safety
2. Access and education
3. Financial benefits
4. Economic development
5. Consumer protection

These five key equity principles have been adapted to our EPIC topics as follows:

Health and Safety

SCE plans to direct EPIC projects to optimize the health of our most vulnerable customers in the communities we serve by advancing the grid to allow greater amounts of clean energy resources. These

[32] PG&E, EPIC; SCE, EPIC; SDG&E, EPIC.

[33] Follows CEC definitions: Disadvantaged Communities are those designated under Health and Safety Code Section 39711 as representing the 25 percent highest-scoring census tracts in the California Communities Environmental Health Screening (CalEnviroScreen) Tool. Under-resourced Communities are disadvantaged and low-income communities as defined Assembly Bill (AB) 523, California Native American Tribes, and other underrepresented groups.

grid advancements enable greater amounts of clean energy resources, which provides health benefits through improved air quality. Improved grid flexibility will increase grid resilience, which provides safety benefits. Health and safety benefits include improved air quality and resiliency, while helping to address climate change vulnerabilities. In general, DACs and under-resourced communities' benefit from:

- Reduced emissions from transportation electrification and customer adoption of other clean energy resources,
- Increased reliability resulting from improved situational awareness, and
- Fewer outages and increased amounts of clean DERs through increased load flexibility

Access and Education

SCE encourages adoption of emerging technologies for grid advancement in DACs and under-resourced communities. SCE's EPIC 4 projects will address community priorities, support engagement among diverse stakeholders, help encourage community-based organizations to become key project partners, and support small and diverse businesses. SCE plans to perform targeted outreach to DACs, as well as widely broadcasting announcements for its EPIC 4 project workshops to create meaningful engagement to help ensure the technologies being reviewed and evaluated are applicable to community interests and responsive to these communities' needs.

Financial Benefits

SCE's EPIC projects will help advance grid capabilities that provide financial benefits. Where possible, SCE intends to prioritize the use of DACs and under-resourced communities for EPIC 4 projects to improve energy equity in these communities.

Economic Development

SCE's EPIC Program supports economic development and job growth through working with vendors, including small and diverse businesses to test and evaluate clean, emerging technologies to advance the grid. These procurement opportunities, especially for field demonstrations located in DACs, helps encourage hiring of low-income, disadvantaged and underrepresented populations within these communities.

Consumer Protection

EPIC limits the Utilities to grid demonstrations and thus SCE's projects do not directly address consumer protection. However, SCE notes that the Utilities' EPIC demonstrations in general help to advance the adoption of emerging clean energy technologies by better integrating these resources on the grid.

Table 2 provides a mapping of four of DACAG's five key equity principles to SCE's EPIC 4 Investment Plan. Consumer protection is not included because it is not directly addressed by SCE's projects.

While the equity principles apply broadly across SCE's EPIC portfolio, the matrix identifies which topics have the greatest potential for benefiting DACs and under-resourced communities.

Table 2: EPIC 4 Equity Matrix

Topic	Health and Safety	Access and Education	Financial Benefits	Economic Development
Adaptive protection	X			
Ultra low-latency communications				

Ubiquitous situational awareness	X			
High capacity throughput & protection	**X**			
Seamless grid flexibility	**X**			
Localized & edge control		**X**	**y**	**y**
Inertia substitution				
Customer load flexibility		**X**	**X**	**y**
Energy buffering				
Bidirectional power flow		**X**	**y**	**y**
Islanding & Reconfigurability	**X**			
Hardening and remediation	**X**	**X**		
Safety and work methods advancement	**X**	**X**		**y**
Data driven operations	**X**	**X**		**X**
End-to-end advanced simulations and analytics	**X**	**X**	**X**	**X**

Marked where applicable, X = direct benefit; y = indirect benefit

V. Overview of investment plan framework and budget allocation

The Utilities have coordinated their respective EPIC 4 Plans to use the same structure as the CEC's EPIC 4 Investment Plans that apply to the technology demonstration area.[34] The Utilities propose three Strategic Objectives and within these themes of strategic importance, SCE proposes six Strategic Initiatives. The Strategic Initiatives represent opportunities and/or challenges for the grid within these Strategic Objectives. As mentioned earlier in the "Summary of stakeholder engagement in investment planning process, internal coordination,"[35] SCE mapped its EPIC 4 Investment Plan with its vision for the future of the grid and its recent CAVA filing. Consequently, SCE's initiatives are similar to the CEC's, but with slight modifications to focus solely on demonstrations and to include SCE's vision to achieve a more reliable, resilient and cleaner future grid. SCE further proposes 15 Research Topics. The Research Topic sections of this investment plan provide details on how SCE plans to operationalize the Strategic Initiatives.

The Commission authorized SCE's EPIC 4 budget of $76,035,000.[36] SCE has no uncommitted EPIC 3 funds available to offset the authorized EPIC 4 budget. SCE requests a full five-years to commit funds, consistent with the Commission's guidance for EPIC 3.[37] The Commission directed the Utilities "to propose funding levels for the Strategic Initiatives."[38] In Table 3 below, SCE presents an overview of its three Strategic Objectives and six Strategic Initiatives. Following the Commission's guidance, SCE proposes its EPIC 4 budget for each of its six Strategic Initiatives in Table 3 below.

[34] EPIC is comprised of the following 3 areas: applied research, technology demonstrations and market facilitation, D.12-05-037, OP 3, at pp. 99-100.
[35] Keep track of Report # for reference
[36] D.21-11-028, Appendix B, at p. B-3.
[37] The utility administrators are authorized to fund their EPIC 3 projects for a full 36 months from the effective date of this decision, rather than only through the end of 2020, D.18-10-052, OP 7, at p. 153.
[38] D.21-11-028, OP 8 at p. 57.

Table 3: SCE's EPIC 4 (2021-2025) Budget

Funding Item	Amount
Strategic Objective A: Create a More Nimble Grid to Maintain Reliability as California Transitions to 100 Percent Clean Energy	
Strategic Initiative: T&D Foundational Technologies	$10,500,000
Strategic Initiative: T&D Situational Capabilities	$13,300,000
Strategic Objective B: Increase the Value Proposition of Distributed Energy Resources to Customers and the Grid	
Strategic Initiative: Energy Management Foundational Technologies	$14,000,000
Strategic Initiative: Energy Management Situational Capabilities	$13,200,000
Strategic Objective C: Guide California's Transition to a Zero-Carbon Energy System that is Climate-Resilient and Meets Environmental Goals	
Strategic Initiative: Digital Transformation	$8,400,000
Strategic Initiative: Vulnerabilities, Threats, and Hazard Reduction	$ 8,651,325
CPUC Administration (.05%)	$380,175
SCE Administration (.10%)	$7,603,500
Total	**$76,035,000**

VI. Strategic Objective A: Create a More Nimble Grid to Maintain Reliability as California Transitions to 100 Percent Clean Energy

As California transitions toward a grid that supports 100 percent clean energy, significant operational challenges will need to be overcome. The electric grid was designed to support the flow of energy from centralized generation facilities to customers. However, the grid of tomorrow needs to support ubiquitous energy resources at all levels of the grid with two-way flow of electricity. To enable effective integration of energy resources at all levels of the grid, there needs to be substantial changes to the way the grid is designed, operated and maintained.

Under Strategic Objective A, SCE will pursue the following two Strategic Initiatives:

- T&D Foundational Technologies
- T&D Situational Capabilities

Strategic Initiative: T&D Foundational Technologies

To achieve California's environmental and energy policy goals, which will necessitate a rapid acceleration in customer adoption of DERs and continued improvements to grid reliability, utilities will need to optimize monitoring and control of grid devices. T&D foundational technology Research Topics will include the evaluation and demonstration of pre-commercial hardware and software applications to increase grid monitoring, protection and control, which will be critical to enabling a more flexible grid. SCE proposes to focus on the following Research Topics:

- Adaptive Protection
- Ultra-low-latency Communications
- Ubiquitous Situational Awareness

Research Topic: Adaptive Protection

Innovation Need

To safely integrate and optimize increasing amounts of DERs and a more climate resilient grid, the protection system requires the ability to adapt to different system conditions. As the number of DERs connected to the grid increases, adaptive protection should adjust to changes in the power system configuration. As the system configuration changes with DERs coming on- and offline, the protection system should be able to adjust settings, setting groups, and/or protection functions/logic in one or more relays to adapt to the system changes. If the protection system is not properly configured to a given grid condition, it may become overly sensitive, adversely impacting reliability; or it could be insufficiently sensitive, increasing safety and equipment damage risks.

Topic Description

An Adaptive Protection System (APS) is a real-time online application that modifies the preferred protective response based on a change in system conditions, business rules, or forecasted reconfiguration in a timely manner by means of externally generated signals or control actions. Many of the foundational communication and control capabilities required to implement APS will be put in place through SCE's Grid Modernization program, but APS algorithms/control logic is more nascent and thus better suited to EPIC.

APS will determine when either the forecasted or real-time distribution system conditions meet certain thresholds or conditions that necessitate a change to protection settings. The APS will determine the correct protection settings to be changed based on its analyses. The APS will also determine the required modifications to the protection scheme and the conditions for implementing the new protection settings. The APS will then send commands to change protection settings/functions to the appropriate devices. The APS should also support centralized training for system operators and protection engineers.

Protection relays will need to evolve from dedicated appliances to become flexible, software-based applications that adapt quickly to evolving grid needs. To achieve this flexibility, relays will be converted from their dedicated hardware to virtualized applications that provide the necessary redundancy, availability, and flexibility. This will enable relays to be upgraded and replaced quickly to add the functionality needed to support evolving grid needs while also maintaining reliability and cybersecurity.

A more advanced APS would be based on machine learning. This type of system would still collect real time voltage and current measurements like traditional protection. However, rather than utilizing the more traditional protection algorithms for fault detection, the machine learning application would continuously evaluate the state of the grid, looking for abnormalities that indicate the need to de-energize the circuit.

Expected Outcomes

This Research Topic is intended to provide:

- A coordinated set of protection settings arranged for a specific circuit configuration
- Demonstration results of machine learning "on the edge" to successfully identify fault locations
- The best means to isolate a fault with minimal impact to customers
- Feedback to the Grid Management System's APS design requirements

- Identification of protection device requirements that meet the systems goals
- Establishment of the existing state of machine learning-based protection

Metrics and Performance Indicators

Advancements in this Research Topic could drive improvements in the following metrics:

- Reduction in false trips of protection equipment
- Reduction in delayed trips of protection equipment
- Reliability metrics (SAIDI, SAIFI and MAIFI)
- Avoided DER curtailment due to over-generation
- Increased DER hosting capacity

Background, Previous Projects and Technology Trends

Most digital relays can already support multiple settings groups. The protection settings that are normally implemented typically address the normal grid configuration, and a few likely alternate configurations. As such, there is an opportunity for further advancement. In general, these settings provide adequate protection, but coordination using the alternate configurations may be sub-optimal.

References

1) V. Ferrari and Y. Lopes, "Dynamic Adaptive Protection based on IEC 61850," in IEEE Latin America Transactions, vol. 18, no. 07, pp. 1302-1310, July 2020, doi: 10.1109/TLA.2020.9099773.
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4) V. Papaspiliotopoulos, G. Korres, V. Kleftakis and N. Hatziargyriou, "Hardware-in-the-loop design and optimal setting of adaptive protection schemes for distribution systems with distributed generation," 2017 IEEE Power & Energy Society General Meeting, 2017, pp. 1-1, doi: 10.1109/PESGM.2017.8274178.
5) M. Uzair, L. Li, J. G. Zhu and M. Eskandari, "A protection scheme for AC microgrids based on multi-agent system combined with machine learning," 2019 29th Australasian Universities Power Engineering Conference (AUPEC), 2019, pp. 1-6, doi: 10.1109/AUPEC48547.2019.211845.

Primary Users and Beneficiaries

The primary user and beneficiary of this Research Topic include the following:

System Operators: would benefit from protection that can adapt and be flexible to changing system configurations.

Guiding Principles

This Research Topic is intended to advance grid protection and coordination capabilities to enhance customer safety and reduce outage frequency and duration.

1) **Safety:** This topic will test and evaluate emerging technologies, strategies, and approaches to increase the flexibility and adaptability of protection systems. Reducing situations where the protection settings are insufficiently sensitive should increase safety and reduce the risk of damaging equipment.
2) **Reliability:** This topic directly supports increased reliability, because as more DERs connect to the grid, adaptive protection has the potential to help integrate these assets in a manner that enables them to further advance reliability.

Mapping of the planned investments to the electricity system value chain

Table 4 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 4: Adaptive Protection Research Topic Mapping to the Electricity System Value Chain

Electricity System Value Chain	Interaction
i. Grid operations/market design	X
ii. Generation	X
iii. Transmission	X
iv. Distribution	X
v. Demand-side management	

Research Topic: Ultra Low-latency Communications

Innovation Need

SCE is currently deploying a Field Area Network (FAN) that will provide sub-second round trip latency (100 millisecond), high-bandwidth throughput, peer-to-peer communications, edge intelligence, scalability within coverage areas, and secure communications between field devices and back office systems. The FAN will initially be deployed using 4G broadband cellular technology, which exceeds the performance and capabilities of SCE's current wireless network. This FAN will also be 5G-ready, meaning that it will be able to support 5G radios installed on edge devices once there is a need and 5G radios are more widely available and in use. It is possible that advances in grid control and protection functionality, coupled with the maturity of Internet of Things (IoT) devices, such as next-generation smart meters, could exceed the capabilities of SCE's current 4G-based FAN deployment. As IoT technologies evolve and begin to be deployed, SCE's communication infrastructure will need to evolve as well. This could potentially require incremental investments in the same FAN to gain additional geographic coverage, redundancy of cell sites, and/or different radio technology.

Topic Description

The accelerated increase in the number of DERs interconnecting to SCE's system is driving the need for improved situational awareness and control of the DERs. The availability of next generation protection devices, such as fault clearing switches and remote fault indicators, coupled with the increase of DERs, has driven the need for advanced protection schemes. Safe and efficient control of these grid devices and DERs will require fast and reliable communications. To meet this need, Ultra Low-latency Communications will build upon the framework of SCE's FAN deployment to explore additional capabilities to assess the need and feasibility of moving to next-generation communication technologies.

To understand the need and feasibility of implementing next-generation communication technologies beyond SCE's current FAN deployment, Ultra Low-latency Communications will cover the following:

- Identify additional communications capabilities required for advanced grid control/protection functionality and next-generation IoT devices that SCE's initial FAN cannot provide. This could include edge computing; Open Phase Detection (OPD), an advanced protection scheme that allows de-energizing falling conductor; support for advanced mobile workforce management applications; and second generation smart metering support.
- Prioritize communication capabilities based on need for the identified use cases.
- Identify next-generation technologies that meet the requirements for ultra-reliable, low-latency communications.
- Investigate and compare the capabilities and constraints of these technologies.
- Demonstrate capabilities through lab testing.
- Perform field demonstrations for "real-world" applicability.

Expected Outcomes

This Research Topic is intended to achieve the following outcomes:

- Validate the potential need and feasibility of implementing ultra-reliable (99.999%), low-latency (i.e., less than 100ms roundtrip latency) communication technologies by understanding their impacts from a capability, performance, cost, maintenance and operational perspective.
- Facilitate the transition to ultra-reliable, low-latency communication technologies for SCE's FAN deployment.
- Accelerate the future adoption of grid control/protection devices and functionality by providing the foundational communications capabilities.

Metrics and Performance Indicators

Advancements in this Research Topic could drive improvements in the following metrics:

- Network Performance: Communications metrics, such as latency, bandwidth, throughput, coverage and security, in comparison to the performance of the initial FAN deployment.
- Reliability: Metrics for network and device reliability in comparison to the initial FAN.
- Costs: For new infrastructure and/or retrofits to existing FAN infrastructure.
- Setup & Configuration: Effort for the setup and configuration of required infrastructure. Remote versus local, web-based UI versus command-line, etc.
- Maintenance: Effort for infrastructure servicing and repairs, including patching on the fly versus requiring a reboot, modular design versus monolithic, etc.

Background, Previous Projects and Technology Trends

The EPIC 2 Next Generation FAN Project was designed to initiate the collection of requirements for the FAN and to support SCE's DRP Demonstration D. Requirements came from various SCE stakeholder groups and ranged from grid device connectivity and grid reliability application needs to cybersecurity and general operations and maintenance needs. Since then, communications technologies have matured and SCE seeks to leverage these next generation technologies for its FAN.

References

1) P. Kansal, A.Bose. "Bandwidth and Latency Requirements for Smart Transmission Grid Applications." IEEE Transactions on Smart Grid, Sept. 2012, vol. 3, issue 3, pp. 1344-1352, doi: 10.1109/TSG.2012.2197229.
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5) D. Chandramouli, R. Liebhart, J. Pirskanen. "5G for the Connected World". Wiley Telecom, 2019.

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include the following:

System Operators: Improved situational awareness due to "real-time" communications providing high throughput, density, and coverage of telemetered devices and improved reliability from enablement of new control and protection devices.

Metering Services: Potential to support second generation smart meter deployment.

Data Analysts: Increase in grid data for analytics facilitated by network improvements.

Guiding Principles

The following is the guiding principle of this Research Topic:

1) **Reliability:** This topic directly supports increased reliability by demonstrating the predictable and consistent low-latency and high-bandwidth services provided by next generation communication technologies. Predictability and consistency are fundamental attributes of a reliable network which will translate into reliability for the devices and applications that traverse it, which should also directly improve reliability.

Mapping of the planned investments to the electricity system value chain, which includes:

Table 5 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 5: Ultra Low-latency Communications Topic Mapping to the Electricity System Value Chain

Electricity System Value Chain	Interaction
i. Grid operations/market design	X
ii. Generation	X
iii. Transmission	X
iv. Distribution	X
v. Demand-side management	X

Research Topic: Ubiquitous Situational Awareness

Innovation Need

The grid is becoming increasingly dynamic due to accelerating adoption of DERs connected to the grid, evolving customer behavior, and an increase in climate-driven hazards to asset health. This is driving the need for enhanced situational awareness that provides operators, engineers, and other stakeholders with real-time visibility throughout the grid with a high degree of spatial granularity.

Topic Description

This Research Topic will demonstrate and evaluate the ability to visualize the condition of the entire electric grid in real-time to promptly respond to abnormal events, such as natural disasters and system imbalances. This topic will also demonstrate innovative software and hardware solutions for sensing and monitoring grid assets. Successfully demonstrated solutions will provide operators and other stakeholders with information to make more informed decisions based on real-time, high-resolution analytics.

Expected Outcomes

This Research Topic is intended to provide:

- Demonstration results of a digital representation of a portion of the electric grid that reflects the real-time status of the grid assets.
- Additional relevant data about SCE's grid, including factors impacting the grid.
- Demonstration results of the efficient visualization and interpretation of multiple data sources—data that we already collect combined with additional data collected from hardware deployed for this topic.

Metrics and Performance Indicators

Advancements in this Research Topic could drive improvements in the following metrics:

- Improved reliability and resiliency due to more data-informed decision making from operators. Operators will have more context and insights from machine learning algorithms to make real time decisions. There will be control decisions to restore power faster and optimize the control of the assets to minimize the impact on customers.
- Reduced risk of wildfire ignition by identifying potential ignition events before the ignitions occur.
- Reduced number of "unknown events" in outage event logs by using data and machine learning to provide stakeholders more insights and enable them to take any proper action they need to

take. Improved understanding of "unknown events" should result in fewer outage events over the long term. Improving understanding should lead to more informed solutions to the causes of outage events.

Background, Previous Projects and Technology Trends

SCE's Wildfire Prevention & Resiliency Technologies Demonstration[39] sub-project "distribution waveform analytics" focuses on predicting grid events that could lead to wildfires. The outcome of the project will be software that will provide engineers and operators visibility and a warning when certain signatures are identified via machine learning models. This project leverages Supervisory Control and Data Acquisition (SCADA) data and Digital Fault Recording (DFR) data to develop machine learning models.

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include the following:

Operations Engineers: currently making real time decisions to support grid operations.

Wildfire Response Team: needs real-time information to make decisions for preventing and responding to wildfires.

Field Engineers: need to respond to abnormal events in the distribution system through real-time analysis and troubleshooting.

Guiding Principles

This Research Topic is intended to advance situational awareness capabilities to provide multiple sources of ratepayer benefits:

1) **Reliability:** This topic directly supports increased reliability by demonstrating hardware and software that reflect real-time grid conditions. Based on that information, operators and automation schemes can restore service to customers more quickly—or potentially respond to abnormal grid conditions before they result in an outage.
2) **Resiliency:** Resiliency could be improved by leveraging real-time information and an accurate representation of the grid to optimize power flows and maintain power to as many customers as possible even through an extreme weather event.
3) **Wildfire Mitigation:** Wildfire mitigation could result from improved situational awareness that relies on real-time, granular grid telemetry data. This data will provide information to protection and control systems to enable quicker responses to grid events that could lead to wildfire ignition.
4) **Safety:** Improved situational awareness could inform analysis and mitigation activities that improve public safety.

Mapping of the planned investments to the electricity system value chain, which includes:

Table 6 summarizes the mapping of this Research Topic to the electricity system value chain:

[39] Proposed in the joint Utilities' EPIC Research Administration Plan (RAP) Application, Appendix E, at p. E-1. Approved by the Commission in D.XX-XX-XXX.

Table 6: **Ubiquitous Situational Awareness Topic Mapping to the Electricity System Value Chain**

Electricity Value Chain	Interaction
i. Grid operations/market design	
ii. Generation	
iii. Transmission	X
iv. Distribution	X
v. Demand-side management	

Strategic Initiative: T&D Situational Capabilities

To meet the increased load growth projected for transportation electrification and building electrification while maintaining affordability, we need to better utilize existing grid facilities. The T&D Situational Capabilities Strategic Initiative examines how to increase utilization by increasing throughput on a given circuit and by increasing grid operations flexibility—such that we can further optimize how multiple circuits are operated together. The Research Topics for this initiative include:

- High-Capacity Throughput and Protection
- Seamless Grid Flexibility

Research Topic: High Capacity Throughput and Protection

Innovation Need

In the past, to address load growth needs utilities installed new infrastructure to increase capacity. This infrastructure facilitated the transfer of energy from centralized generation facilities to distributed loads. As DERs begin to offset some increased load, there needs to be a different approach to infrastructure enhancements. Moreover, monitoring, protection, automation and control needs will increase with greater utilization of the T&D system. Consequently, utilities will require non-traditional (dynamic control) methods of controlling and optimizing the flow of energy.

Topic Description

As California transitions to 100 percent clean energy and additional sectors of the California economy convert from fossil fuels to electricity, load growth and peak demand are expected to increase. Concurrently, climate change is expected to limit the expansion of grid facilities in sensitive areas that are subject to wildfires. Therefore, meeting increased load growth while managing the impacts of climate change will require greater utilization of both new and existing T&D assets. The increased utilization of these T&D assets will also need more intensive protection, automation, monitoring, and control to identify impacts from increased use and to proactively mitigate these impacts. This topic will also demonstrate modern, pre-commercial protection technologies that would allow greater flexibility to system changes.

Expected Outcomes

This Research Topic is intended to provide:

- Increased utilization of T&D assets to meet increased load growth and peak demand.

- Lab demonstration results examining new protection, automation and control applications, as well as new hardware for monitoring and control. Equipment to be examined could include DC systems, Solid State equipment, and distributed high speed sensors.

Metrics and Performance Indicators

Advancements in this Research Topic could drive improvements in the following metrics:

- Fewer protection issues on circuits with high penetration of inverter-based resources.
- Evaluate and report on new technologies that enhance hosting capacity, documenting the proposed increase (i.e., increase in DER integration capacity).
- Increase asset utilization (e.g., average load compared to planned loading limit (PLL); increases in PLL, etc.)

Background, Previous Projects and Technology Trends

The electric utility industry has, in the past, been very successful at adapting older technologies to new applications. This tendency, along with the introduction of new technologies, has allowed the industry to be flexible and meet new challenges. Using energy storage in lieu of new distribution facilities is a successful implementation of this concept.

References

1) M. Uzair, L. Li, J. G. Zhu and M. Eskandari, "A protection scheme for AC microgrids based on multi-agent system combined with machine learning," 2019 29th Australasian Universities Power Engineering Conference (AUPEC), 2019, pp. 1-6, doi: 10.1109/AUPEC48547.2019.211845.
2) http://www.pes-psrc.org/kb/published/reports/IEEE_PES_PSRC_WG K15_Report_CPC_Dec_2015.pdf

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include the following:

Customers*:* intending to install inverter-based resources.

Utility Planning Engineers: identify alternatives to reconductoring that will increase utilization of infrastructure.

Utility protection and planning engineers: needing to manage the impact of substantial backflow on the grid due to increased adoption of inverter-based resources.

Guiding Principles

This Research Topic is intended to advance capabilities for managing and optimizing grid resources, which could result in the following customer benefits:

1) **Safety:** Enhance the public and employee safety by introducing new technology and techniques to quickly identify and isolate faults.
2) **Reliability:** Minimize customer outages by quickly identifying the minimal outage required to isolate the fault.
3) **Affordability:** Utilize new techniques and technology to maximize utilization of existing infrastructure.

Mapping of the planned investments to the electricity system value chain, which includes:

Table 8 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 8: High Capacity Throughput and Protection Topic Mapping to the Electricity System Value Chain

Electricity Value Chain	Interaction
i. Grid operations/market design	
ii. Generation	X
iii. Transmission	X
iv. Distribution	X
v. Demand-side management	

Research Topic: Seamless Grid Flexibility

Innovation Need

Electric demand in southern California is expected to increase substantially in the future due to transportation and building electrification. Energy storage and other DERs will help satisfy some of this increased electricity demand. Operational flexibility will be needed to maintain system stability as generation and load fluctuate and become less predictable. Grid reliability is heavily dependent upon restoring power to customers quickly following a fault. To maintain and potentially enhance grid reliability, utilities will need to leverage and optimize the new DERs as additional sources of power, along with neighboring substations. The primary objective of the Seamless Grid Flexibility Research Topic is to maximize the number of restored customers following an outage by using energy storage and other DERs.

Innovation in power system assets and optimizing their placement and operation is necessary to help support power system quality metrics, such as voltage and frequency. The electric grid will also need technology to maintain flexibility for resiliency— to ride through extreme events that restrict supply of generation resources or increase demand to the electric grid. The grid will need innovation in devices, algorithms and software to enable fast responses to system changes to ensure a seamless, stable, reliable grid. The type of response needed to address grid changes will depend on the system requirements but could include functions such as real/reactive power balancing, switching, and control optimization.

Topic Description

As SCE's grid becomes more dynamic and prone to more unpredictable weather-driven events, innovation will be required to maintain system reliability, resiliency, power quality and safety. We will need to deploy grid technologies that focus on maintaining stability and enabling operational flexibility to address the DER intermittency and fluctuating demand in real-time. The topic will demonstrate innovation in hardware devices, including next generation technologies capable of responding to various grid needs more quickly and with greater precision. The evaluation of next generation technologies may include solid state technology, AC/DC hybrid systems networks, and DC distribution systems. Software solutions will also be investigated and demonstrated to facilitate flexible, real-time responses to grid needs. Finally, we will aim to demonstrate a software/hardware system to achieve higher level control and optimization of customer and utility assets to create a more nimble distribution system. This demonstration of a software/hardware system may include demonstrating interoperability between typical devices in a distribution system and software to perform a specific protection, automation, or control function using emerging communication protocols.

Expected Outcomes

This Research Topic is intended to provide:

1. Demonstration results of solid state technology that could support grid flexibility in response to high-DER penetration.
2. Demonstration results of software and machine learning algorithms that optimize control of distribution assets to support grid flexibility.
3. Demonstration results of peer-to-peer communication assisted protection and control schemes between controllers from different vendors to maintain grid flexibility during events that affect reliability and resiliency.

Metrics and Performance Indicators

Advancements in this Research Topic could drive improvements in the following metrics:

- Improved distribution-level power quality metrics
- Reliability indices improvements (MAIFI, SAIDI, SAIFI)
- Avoided DER curtailment

Background, Previous Projects and Technology Trends

A previous project that was started under the EPIC 3 portfolio is called the "Storage Based Distribution DC Link" project. SCE is investigating using a bi-directional inverter to demonstrate the feasibility of managing the loading on two distribution circuits simultaneously, thereby reducing the risk of an overload condition on one of the circuits. This project relies on the bidirectional inverter, which is similar to a back-to-back converter with perhaps some modifications to ensure a bidirectional power flow between circuits connected to both AC sides. The project will also demonstrate the feasibility of a battery energy storage system (BESS) being able to manage controlled line loading on two adjacent circuits simultaneously via a DC link. This could prevent line overloads or duct bank temperature violations, optimize local voltage, and support the integration of renewable resources.

References

1) Smart Grid Flexibility Markets – Entering an Era of Localization https://www.cleantech.com/smart-grid-flexibility-markets-entering-an-era-of-localization/#:~:text=%E2%80%9CGrid%20Flexibility%E2%80%9D%20refers%20to%20the,variable%20renewables%20into%20the%20grid.
2) Hamed Shadfar,Mehrdad Ghorbani Pashakolaei,Asghar Akbari Foroud "Solid-state transformers: An overview of the concept, topology, and its applications in the smart grid"

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include the following:

System Operators: Higher situational awareness on distribution grid would benefit System Operator real-time grid activities with fewer grid disturbances.

Distribution Automation team: Able to deploy and maintain grid device controllers configured to be interoperable.

Distribution Engineering: Data can be input to distribution planning tools for circuit analysis.

Guiding Principles

The following are the guiding principles of this Research Topic:

1) **Reliability:** Reliability improvements will be demonstrated by leveraging software and hardware solutions that can help the grid ride through voltage and frequency anomalies in real time and as a result minimize relay tripping.
2) **Safety:** Peer-to-peer communications assisted protection schemes would reduce the number of momentary interruptions as well as reduce the need for testing into a fault to determine the fault location. Reducing momentary interruptions and the number of tests (through reclosing) should support public safety by reducing their potential exposure to high-voltage equipment.
3) **Environmental Sustainability:** Improved grid flexibility should allow system operators to respond more quickly to grid instability through reconfiguration, thereby avoiding having to curtail DERs in the event of an overload or other abnormal condition.

A mapping of the planned investments to the electricity system value chain, which includes:

Table 9 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 9: Seamless Grid Flexibility Topic Mapping to the Electricity System Value Chain

Electricity Value Chain	Interaction
i. Grid operations/market design	
ii. Generation	
iii. Transmission	X
iv. Distribution	X
v. Demand-side management	

VII. Strategic Objective B: Increase the Value Proposition of Distributed Energy Resources to Customers and the Grid

Substantial increases in the number of DERs on the electric grid will be instrumental for California to achieve its energy and environmental policy goals. While DERs have numerous potential benefits (e.g., load flexibility, peak demand reduction and/or distribution deferral upgrades for grid operators), grid capabilities must be enhanced to fully realize these DER benefits. In addition to the basic function of delivering electricity, traditional synchronous generating sources also provide a stable frequency and response to variable demands. As these types of traditional resources are displaced by DERs, the grid will continue to need these grid services. Additional services required by the grid include: grid capacity (basic, load shaping and shifting, and ramping reserve capacity), constraint management, cold load pickup, frequency control and response, black start, resilience to disturbances, and voltage support.[40]

[40] "IEEE Guide for Distributed Energy Resources Management Systems (DERMS) Functional Specification," in IEEE Std 2030.11-2021, vol., no., pp.1-61, 9 June 2021, doi: 10.1109/IEEESTD.2021.9447316.

Integrating a large quantity of renewable inverter-based resources (IBR) to replace traditional generation while providing customers with the energy usage flexibility will change the physical location, capacity and nature of how these services are provided. The ability of DERs to deliver these services needs to be demonstrated.

Under Strategic Objective B, SCE will pursue the following two Strategic Initiatives:

- Energy Management Foundational Technologies
- Energy Management Situational Capabilities

Strategic Initiative: Energy Management Foundational Technologies

The proliferation of diverse DERs presents new challenges for planning and operating the power system. Instead of a small number of large power plants, electric system operators will need to manage a large number of small DERs. To meet this challenge, utilities will need to invest in emerging technologies with the ability to manage a large number of distributed resources, provide equivalent functionality to traditional synchronous generation, and maximize customer flexibility. Energy management foundational technologies will enhance the reliable operation of the power system, even when considering a diverse mix of resources from community to community or region to region. SCE proposes the following Research Topics:

- Localized and Edge Control
- Inertia Substitution
- Customer Load Flexibility

Research Topic: Localized and Edge Control

Innovation Need

Californians' energy demands, consumption patterns and expectations for electricity reliability continue to evolve. In the near future, local energy resources, renewable power generation, and microgrid systems will significantly affect how utilities operate their distribution systems. To provide reliable power to their customers, utilities will need improved grid flexibility enabled by localized and edge control, where locally placed control devices take action in response to changing conditions. Edge monitoring, control, and situational awareness innovations are also needed to ensure that DERs are fully optimized. As the amount of available data increases, control systems will need to process more information more quickly. Processing data at the edge will help control systems process information faster and minimize the amount of data that needs to be transferred to traditional grid control centers, thereby reducing the communication network traffic.

Topic Description

SCE's distribution system includes over four thousand distribution feeders, while each feeder hosts multiple control and protection devices. The existing control centers, communication infrastructure, and distribution automation and control devices will need additional capabilities to meet the needs of grid management in the future. As the amount of available grid data increases, advanced and edge control technologies have the potential to quickly process large amounts of data. These technologies can also take local action as necessary to meet the future grid's dynamics and adaptability needs, without having to transfer all data to back office control systems (which can delay the response). This topic aims to demonstrate the capabilities of localized and edge control technologies:

- Advanced software
- Communication protocols and related edge hardware
- Renewable energy generation
- Microgrid systems
- Local energy resources
- Distribution automation devices
- Variable loads, such as EV charging stations, net-zero communities, and industrial and high priority loads

Expected Outcomes

This Research Topic is intended to provide:

1. Documentation of how to process data and control distribution automation, protection and monitoring devices at the edge to improve the speed of processing data and performing localized control operations, without the need to transfer large amounts of data to a centralized control center.
2. Requirements to be included in future RFPs to provide localized and edge control capabilities for distribution automation, electric transportation, demand response, renewable energy generation and storage devices.
3. Requirements that will help improve the future grid's reliability by helping to enable adaptive control system capabilities.
4. Requirements for a secure and smart edge computing platform.

Metrics and Performance Indicators

Advancements in this Research Topic could drive improvements in the following metrics:

- Improved reliability metrics (SAIDI, SAIFI and MAIFI) enabled by communications-assisted protection and localized edge control.
- Avoided DER curtailment due to over-generation
- Increased use of DERs to provide grid services (e.g., voltage regulation)
- Faster response to unsafe operating conditions (i.e., downed wires)
- Increased grid stability
- Lower cost communications infrastructure requirements

Background, Previous Projects, and Technology Trends

SCE currently uses various control applications from its Distribution and Energy Management System such as Distribution Volt/VAR Control, which optimize volts and VARs on a circuit, and the Energy Storage Constraint Management which limits the charging operations of grid-scale battery energy storage systems to support grid reliability.

SCE recently evaluated more decentralized control with its Remote Integrated Switch (RIS) Project, which evaluated the ability to automatically detect distribution system fault conditions, interrupt faults, isolate faulted equipment and restore power to customers. The pilot used existing network infrastructure and protocols, but the next phase looks to explore the use of modern protocols and communications to improve on fault response times.

The deployment of more localized edge control would complement existing centralized monitoring and control to ensure system optimization and reliability.

References

1) Stinskiy, A. Smit, C. Huff, A. Elandaloussi, D. Ro, M. Balestrieri. "IEC61850 based distribution automation system testing with RTDS and 4G LTE." 2022 75th Annual Conference for Protective Relay Engineers (CPRE), Mar. 2022, DOI: 10.1109/CPRE55809.2022.9776571.
2) Craig Preuss and Lindsey Spencer, "Utilities on the Edge: Powering Transformation with Grid Edge Intelligence," and Doug Houseman, "Field Computing Needs," IEEE Smart Grid, August 2021.
3) Omid Alizadeh-Mousavi, Joël Jaton, "The Roles of Edge Computing in Monitoring, Control, Management and Digitalization of Distribution Grids," IEEE Smart Grid, February 2019.

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include the following:

Distribution operators, engineers, and distribution planners: the primary users that would be able to optimize for the evolving needs of a grid with high amounts of DERs.

Customers: the primary beneficiaries from a highly automated, flexible, and reliable grid integrating a variety of DERs.

Guiding Principles

The following are the guiding principles of this Research Topic:

1) **Safety:** Utilize edge computing capabilities to identify local safety issues not apparent to other systems.
2) **Reliability:** Enhance localized control operations to minimize and shorten customers outages.
3) **Affordability:** Processing data locally and only forwarding the required information will reduce the needed communication enhancements.
4) **Environmental Sustainability:** Utilize edge computing and DERs to enable the ability to dynamically island portions of the grid during times of extreme environmental impacts.

Mapping of the planned investments to the electricity system value chain, which includes:

Table 10 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 10: Localized and Edge Control Topic Mapping to the Electricity System Value Chain

Electricity Value Chain	Interaction
i. Grid operations/market design	X
ii. Generation	
iii. Transmission	
iv. Distribution	X
v. Demand-side management	X

Research Topic: Inertia Substitution

Innovation Need

California has enacted a policy to retire traditional generating plants that use *once through cooling*. However, a critical challenge to retiring these facilities is the resulting decline in grid inertia–the rotating mass that enables the grid to ride through disturbances. This loss of inertia introduces four main challenges to grid reliability:

1. The inertia provided by traditional generating facilities is the primary influence for grid stability.
2. The impact of the inertia loss from retiring traditional generating plants is not well understood—including both the nature of the impact and the ability to quantify it.
3. There are gaps in information regarding optimizing grid operations and planning with traditional generating plants in coordination with other resources, such as DERs.
4. Traditional generating plants are insufficient for providing flexible grid operation, which will be needed as customer demand and DERs increase.

Description

This topic aims to understand, enable, and improve grid performances by adopting power electronics technologies, such as next generation inverters to address inertia substitution to achieve reliability and resilience for the future grid. SCE plans to examine the following four interrelated areas of inertia substitution:

1. Understand the low inertia challenges originating from the retirement of traditional generating plants and how inertia substitution technologies could create opportunities to mitigate impacts to the grid.
2. Investigate the full range of inertia substitution technologies' capabilities and constraints to leverage and optimize these resources capabilities.
3. Optimize inertia substitution technologies' planning and operations along with other resources to increase grid reliability.
4. Simulate and demonstrate the inertia substitution technologies to determine performance effectiveness on the grid.

These four related areas of examination are purposefully collective with the first two areas feeding into the third and fourth. The first two areas will establish a baseline understanding of the inertia range optimal for future grid operations and help identify technologies that could support this optimal inertia range. Moreover, these two areas will provide a complete picture of the grid requirements for addressing low inertia and the ability and limitations of other technologies to support the grid during these conditions. The third area will enable operationalization of this information by developing strategies for using these technologies to increase grid reliability. The fourth area integrates the findings from the first three areas to inform and validate the technologies. These four areas of examination are designed to be performed sequentially, but some work can be conducted in parallel and a given project may span multiple areas of examination.

Background, Previous Projects and Technology Trends

Among the various challenges that arise from the retirement of traditional generation facilities is the decline in inertia. The reduction of inertia - if not properly managed - will reduce the grid's stability and reliability. Only a few researchers have investigated the stability limitations of a future grid expected to be dominated by non-traditional generation. In Texas, the Electric Reliability Council of Texas (ERCOT) worked on the inertia issue to understand the technical requirements of a future grid with distributed generation. A demonstration project led by Duke Energy Corporation also focused on inertia as a part of an overall project's objective. However, there is a lack of utility demonstration projects examining inertia substitution technologies.

References

1) Heuberger CF, Mac Dowell N. Real-world challenges with a rapid transition to 100% renewable power systems. Joule 2018;2(3):367–70.
2) Daly P, Flynn D, Cunniffe N. Inertia considerations within unit commitment and economic dispatch for systems with high non-synchronous penetrations. 2015 IEEE Eindhoven PowerTech, PowerTech 2015 IEEE; 2015.
3) Johnson SC, Papageorgiou DJ, Mallapragada DS, Deetjen TA, Rhodes JD, Webber ME. Evaluating rotational inertia as a component of grid reliability with high penetrations of variable renewable energy. Energy 2019;180:258–71.
4) Electric Reliability Council of Texas. Inertia: basic concepts and impacts on the ERCOT Grid. Tech. Rep., ERCOT, Taylor, TX; 2018.
5) Wehner, Jeff, Mohler, David, Gibson, Stuart, Clanin, Jason, Faris, Don, Hooker, Kevin, and Rowand, Michael. Technology Performance Report: Duke Energy Notrees Wind Storage Demonstration Project. United States, 2015

Expected Outcomes

This Research Topic is intended to provide:

- Identification of the grid's current and future inertia needs: A technology roadmap to maximize inertia substitution technology's contributions to reliability, resilience and grid integration.
- Understanding of inertia substitution technology capabilities: A set of data to understand the range and limits of the technologies' flexibility and identification of opportunities at the transmission and distribution levels.
- Inertia substitution technology modeling to optimize planning and operations: A set of modeling approaches to improve grid planning and operations to most effectively utilize these technologies' capabilities.

- Technology operating requirements: A set of requirements and boundaries for a wide operating range of the technologies to ensure the reliability of the grid.

Metrics and Performance Indicators

SCE has identified the following performance indicators to evaluate inertia substitution technology capabilities:

- Power Quality: The topic requires investigating inertia as a service to improve the power quality of the grid. Power quality resulting from inertial response availability will be assessed in terms of response time following a frequency disturbance and/or when inertia is made available. This will provide a framework for incorporating inertial response services based on customer requirements.
- Cost-Benefit: While one technology can mitigate inertia issues, other technologies are almost always available that can also provide equivalent mitigations. A cost-benefit analysis will be used to identify the most cost-effective means to address loss of inertia.

Primary Users and Beneficiaries

SCE's role in addressing the retirement of traditional generation plants and addressing the inertia substitution issue is essential, as challenges addressed by this topic extend beyond the scope of any single utility or industry. The topic will investigate future scenarios, operational paradigms, and technological capabilities that would surpass the traditional considerations of most planners and operators today. Thus, the activities under inertia substitution will benefit industry decision-makers' current and future actions.

Major beneficiaries for inertia substitution work include generation owners and operators, Independent System Operators/Regional Transmission Organizations (ISO/RTOs), regulators, original equipment manufacturers, and environmental organizations. The work is closely aligned with other SCE initiatives and enhances internal cross-functional collaborations between business and strategic planning, transmission planning, grid operations, and reliability coordination.

Guiding Principles

This Research Topic is intended to help address inertia substitution needs to enhance workforce safety, and support reliability and environmental sustainability.

1) **Safety:** Electrical grid safety strongly depends on reliable protection schemes. The proper functioning of protection must guarantee the safety of field personnel, equipment, and continuity of electricity supply, focusing on avoiding blackout conditions. This topic will enhance safety by exploring fault scenarios and approaches to strengthen the protection schemes that ensure safety to field personnel and grid reliability.
2) **Reliability:** A new control approach to mitigate the inertia issue through the selected technologies will be investigated, thereby supporting grid reliability. Improvements to SAIDI and SAIFI resulting from these potential inertia substitution technologies could be estimated.
3) **Environmental Sustainability:** The topic intends to enhance the growth of renewable technologies by addressing the potential challenges that could originate during deployment of these renewable resources. In addition, increased inverter-based inertia substitution technologies can potentially displace fossil-based generation systems, reducing air pollutant emissions.

Mapping of the planned investments to the electricity system value chain, which includes:
Table 11 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 11: **Inertia Substitution Topic Mapping to the Electricity System Value Chain**

Electricity Value Chain	Interaction
i. Grid operations/market design	X
ii. Generation	X
iii. Transmission	X
iv. Distribution	X
v. Demand-side management	

Research Topic: Customer Load Flexibility

Innovation Need
As transportation and building electrification increase, electric services will need to expand to meet future demand. Expansion is needed from generation through the distribution system. New methods and controls are needed to help meet future grid demand and reduce the cost of expanding grid capacity (wires, equipment, and generation).

New approaches to help meet future grid demands include DC service techniques. Most new DERs are native DC sources and loads (i.e., manageable EV charging, solar photovoltaic (PV), fuel cell, battery energy storage, etc.), and conversion to alternating current (AC) creates losses that could be avoided with DC distribution. While most distribution transformers have >98% conversion efficiency, many devices are native DC and average 71% AC to DC conversion efficiency. Shifting to low-voltage DC could therefore yield 15%+ efficiency improvements across a variety of devices.

In addition to DC service techniques, future grid demands will require effective controls and tools that can adapt to changes in grid conditions. Understanding the factors that contribute to changes in grid conditions and applying the appropriate tools will be critical for meeting future grid demands.

Topic Description
This topic will demonstrate methods to establish the parameters for customer flexibility. SCE has divided the customer load flexibility topic into the following three areas:

1. DC Service and Solid-State Transformers: Solid-state transformers can provide higher capacity than existing transformers without occupying additional space. In addition to high power densities, solid state transformers provide many capabilities such as automatically stabilizing voltage, regulating power quality, power flow control, and providing protection/fault isolation capabilities. Solid state transformers can be used to drive energy efficiency while occupying less space than similarly-sized dry/oil-filled AC transformers. In addition to occupying less space, solid state transformers can serve customers with low-voltage DC. DC service components and related systems have safety enhancing implications that could reduce wildfire risk. DC power distribution systems leverage solid-state transformers equipped with voltage and current sensing. Solid state transformers can rapidly detect and isolate faults (tens to hundreds of

microseconds depending on the fault) as compared to traditional AC protection systems that typically operate in the millisecond range. These systems may provide the following capabilities:

- Active and reactive power control
- Voltage, phase, and frequency control including harmonics
- Bidirectional power flow with isolation
- Hybrid (i.e., AC and DC) and multi-frequency systems (e.g., 50 Hz, 60 Hz, 120 Hz) with multiple ports
- Riding through system faults and disruptions (e.g., HVRT, LVRT)
- Self-aware, secure, and internal fault tolerance with local intelligence and built-in cyber-physical security

2. Improving DER Aggregation Utilization: The ability to connect with and leverage aggregators of growing numbers of DERs through appropriate controls and cybersecurity will increase the beneficial use of SCE's Grid Management System.
3. Vehicle Grid Integration (VGI) Valuation in Commercial Context: Topics in this area include managed charging, demand response, advanced metering and submetering, tariffs and their application, bidirectional charging, and vehicle-to-grid resiliency and backup power. As customers adopt EVs, it will be crucial to demonstrate new methods, equipment and technical controls to integrate these EVs onto the electric grid. Integration of the vehicles to provide grid services will provide benefits to utility operators and customers.

Expected Outcomes

This topic will help describe the systems needed to increase flexible load capabilities, such as improving supply quality and increasing energy efficiency to customers in a DER-heavy future. The results will also help advance methods for increasing grid flexibility and intelligence to decouple sensitive loads from grid disturbances, such as wildfires. The topic will also help to apply technical methods to control demand and optimize DERs. Improvements to DER aggregation intelligence will help to increase grid flexibility. This topic aims to demonstrate the ability to connect with and secure high levels of DERs and DER aggregators to execute controls for grid management. Lastly, the topic will evaluate advanced techniques for identifying customer load flexibility in commercial applications, advancing equipment such as load management systems, DER and EV integration, V2G systems, and advanced metering systems to help determine the value of VGI in a commercial context.

Metrics and Performance Indicators

SCE has identified the following metrics and performance indicators for this topic:

- **Wildfire Risk Reduction:** DC protection systems could identify and isolate faults up to 37 times faster than traditional AC relays assuming a 1-cycle (16.67 ms) trip time. Such fast response times could reduce the risk in operating DC lines in high wildfire risk areas and could be paired with covered conductor technology for a significantly more arc-flash resilient line. This may also significantly decrease the need to perform public safety power shutoff (PSPS) in high wildfire risk areas.
- **Increased VGI Load Flexibility:** Increase in EV load designated as a flexibility resource.
- **Energy Cost:**
    a. Increase energy efficiency by optimizing between the use of AC and DC topologies/networks to minimize total system losses while facilitating the integration of multiple types of distributed energy resources.

   b. Reduce grid congestion and losses by maximizing DER utilization via DER aggregators to supply customer demand.

- **Environmental Sustainability:**
   a. Eliminate the need for Sulphur Hexafluoride (SF6), which is often described as the world's worst greenhouse gas. It is 23,500 times more potent than CO2 and is currently used as a dielectric in most transformers and gas insulating switches on the distribution network. SF6 will start to be phased out in California in 2025.
   b. Enabling higher DER penetration levels on our distribution network to supply clean energy with reduced network losses
   c. Improving the grids' ability to host higher EV penetrations to support EV growth. Higher EV adoption will reduce emissions from the transportation sector.
- **Safety, Power Quality, and Reliability (equipment, electricity system)**
   a. Improve supply quality using power flow control for peak management, phase balancing, local voltage control, or active harmonic dampening.
   b. Decoupling loads from the grid via medium-voltage DC-coupled converters can protect the grid against the influence of loads like arc furnaces and large industrial motors or decouple sensitive loads from disturbances in the grid.

Background, Previous Projects and Technology Trends

Many studies over the years have been conducted in the area of customer profiles and behaviors, demand flexibility, solid-state transformers, and demand response. The following references illustrate how these studies and potential future products related to customer load flexibility may benefit the grid and customers. Notably the U.S. Department of Energy has published a roadmap discussing how advanced substations present a tremendous opportunity to improve grid performance using solid-state transformers. Development of advanced solid-state technologies can enable new functionalities, new topologies, and enhanced control of power flow and voltage can increase the grids' overall reliability, resiliency, efficiency, flexibility, and security.

References

1) *Advanced Strategies for Demand Flexibility Management and Customer DER Compensation, Energy Division White Paper and Staff Proposal:* https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-response/demand-response-workshops/advanced-der---demand-flexibility-management/ed-white-paper---advanced-strategies-for-demand-flexibility-management.pdf
2) The US Department of Energy published a Solid State Power Substation Technology Roadmap that outlines a variety of solid-state transformer applications. These applications range from net-zero buildings, integrated generation, and high-voltage direct current.
3) In this paper, Research on Energy Efficiency of DC Distribution System (sciencedirectassets.com), the energy efficiency of DC distribution systems is researched. Efficiency calculation models of feeders and loads are established, efficiencies of AC/DC, DC/DC and DC/AC are analyzed. Moreover, energy efficiencies of an AC system and two DC systems, monopole and bipolar, are calculated and compared. The efficiency improvement of an office building supplied by a DC power system compared to supply by an AC power system is demonstrated. Based on the analysis, it showed that the energy efficiency is higher in a DC distribution system than an AC distribution system.

4) Advanced Grid Research Office of Electricity US Department of Energy, 2020, accessed 3/10/22, https://www.energy.gov/sites/default/files/2020/07/f76/2020%20Solid%20State%20Power%20Substation%20Technology%20Roadmap.pdf – for marked up and commented version see internal copy.
5) Shiqi Ji1*, Marko Laitinen2 , Xingxuan Huang1 , Jingjing Sun1 , Bill Giewont2 , Leon M. Tolbert1,3, Fred Wang1,3 1 Department of Electrical Engineering and Computer Science, University of Tennessee, Knoxville, TN, USA 2 Danfoss Drives, Raleigh, NC, USA 3 Oak Ridge National Laboratory, Oak Ridge, TN, 37831, accessed 3/10/22 https://www.osti.gov/servlets/purl/1471853#:~:text=The%20short%20circuit%20withstand%20time,1.5%20%CE%BCs%20is%20also%20validated.
6) Georgia Tech Research Corporation | arpa-e.energy.gov

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include:

Customers: will have their loads more cost effectively self-managed and optimized and realize higher returns on their DER investments.

DER Aggregators: will be incentivized to use customer DERs to more effectively serve the grid and its customers. DC services can further drive efficiency gains that increase grid capacity while improving reliability. These efficiency gains, VGI optimization, and improved DER Aggregator utilization may help ensure that building and vehicle electrification is served cost-effectively.

Guiding Principles

The following are the guiding principles of this Research Topic:

1) **Safety:** This topic supports improvements to safety, through DC service and solid-state transformers' improved sensing and (37 times) faster fault isolation capabilities that could drastically reduce wildfire ignition risk.
2) **Reliability:** This topic supports increasing reliability by leveraging VGI load flexibility and DER aggregator resources to balance electricity supply and demand as demand growth increases from electrification. This topic also supports improved system reliability by examining the use of solid-state transformer power quality management capabilities.
3) **Environmental Sustainability:** This topic helps enable increasing the amount of DERs o supply customer demand, providing cleaner energy for our customers.

Mapping of the planned investments to the electricity system value chain, which includes:

Table 12 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 12: Customer Load Flexibility Topic Mapping to the Electricity System Value Chain

Electricity Value Chain	Interaction
i. Grid operations/market design	
ii. Generation	
iii. Transmission	
iv. Distribution	X
v. Demand-side management	X

Strategic Initiative: Energy Management Situational Capabilities

Enhancing utility energy management capabilities by leveraging DERs requires further advancement in the areas of energy storage and grid control. The ability to store energy for longer periods and to anticipate when the stored energy will be needed is critical to realizing greater value from DERs. Control systems and strategies that enable the formation of microgrids and management of greater variations in power supply and demand across the grid, especially in areas where DER generation can exceed load at times ("reverse power flow"), will enable increased DER utilization.

The key situational capabilities designed to solve specific grid challenges through DERs will be investigated in the following Research Topics:

- Energy Buffering
- Bidirectional Power Flow
- Islanding and Reconfigurability

Research Topic: Energy Buffering

Innovation Need

As electricity demand increases with higher electrification and DER adoption, additional utility-scale storage will be needed to supplement existing generation resources. The intermittency of solar and wind generation requires energy storage to act as a buffer to ensure that demand for the electric grid can be supported, especially when available solar and/or wind generation is insufficient. Energy storage systems can charge during periods of high renewable generation and discharge during periods of low generation. A significant number of energy storage systems are currently deployed throughout the state that can accomplish this for four to eight hours. These systems can perform energy buffering for one to two days. However, as more traditional non-intermittent, carbon-emitting power generation resources go offline, energy storage systems will be needed to perform energy buffering over longer durations. Depending on the scenario, energy buffering could be needed for several days during multiple cloudy or low wind days, or even weeks when overall solar generation is low, during winter months, for example.

Due to its maturity and cost-effectiveness for four-to -eight hour discharges, most energy storage systems deployed throughout California use lithium-ion battery technology. To perform energy buffering for longer durations (>10 hours), other technologies have the potential to be more cost-effective, but they need to be further tested and evaluated to verify that they can perform energy buffering as intended. In addition, due to the novel nature of these long duration energy storage (LDES) systems, which are generally non-lithium energy storage systems (NoLESS), deployment processes and procedures are less developed than those used for lithium-ion based energy storage technologies.

Energy buffering would support long-term grid needs while also helping to address near-term challenges. The near-term energy buffering use cases do not require LDES systems and could, therefore, likely be addressed by traditional lithium-ion energy storage systems. A significant portion of California's power is still produced by traditional generation (e.g., natural gas and nuclear) that needs to be ramped up or down to match electricity demand. Ramping generation up and down from these sources is not instantaneous and can cause operational issues in areas with high amounts of renewable generation. Clouds rolling over a solar farm, or sudden drops in wind around a wind farm, can cause a steep drop in generation output. Similarly, once clouds move beyond the solar farm, or the winds recover around a wind farm, renewable generation can rapidly increase. Ramping traditional generation up and down is not instantaneous and is often unable to offset the intermittency of renewable generation. BESS inverters can source and sink power almost instantaneously, allowing them to act as a buffer that can make up for sudden drops in renewable generation, and smooth out sudden surges caused by renewable generation returning from high cloud coverage/low wind conditions.

Energy storage can also act as a buffer in other scenarios that cause sudden surges or sags in electricity demand. If a high demand customer trips offline, this causes a sharp decrease in demand that traditional generation cannot easily accommodate. Once the customer goes back online, this could potentially cause a sharp increase in demand. For these scenarios, energy storage can act as a buffer much like it does for intermittent renewable generation.

Topic Description

An analysis of SCE's service territory will be performed to identify where energy buffering using LDES (>10 hours of energy) will be needed in the future. Based on this analysis, technologies that are currently available will be reviewed and a subset of these technologies will be demonstrated in the laboratory and/or through a small field demonstration. Technologies that will be considered include, but are not limited to:

- Flow batteries
- Compressed air
- Liquid air
- Thermal energy storage

In addition, the topic will include an analysis of where energy storage can be deployed to act as a buffer for renewable generation and load intermittency. SCE plans to focus on a location where SCE already has an energy storage system deployed, or where a LDES could potentially be deployed. The ideal scenario would be to either demonstrate energy buffering using an existing BESS or demonstrate a multiuse scenario where a LDES system could be deployed to address long-duration use cases as well as renewable generation/load intermittency use cases.

Expected Outcomes

This Research Topic is intended to provide:

1. Analysis of SCE's service territory to identify deployment locations that are appropriate for energy storage buffering using a BESS, and a qualitative analysis of the benefits of deployment.

2. Demonstration of one or more energy storage technologies appropriate for energy storage buffering.
3. Validation of whether specific technologies can perform energy buffering more cost-effectively than lithium-ion energy storage.
4. Identification of barriers and issues involved with deploying alternative battery energy storage technologies (non-lithium technologies).
5. Depending on the technology type demonstrated, work with the appropriate authority having jurisdiction to understand and develop any formal requirements that need to be created, due to the novel nature of the technology.

Metrics and Performance Indicators

Advancements in this Research Topic could drive improvements in the following metrics:

- Generation Dependability: Expected impact to renewable generation dependability for each technology evaluated.
- Cost of Generation Dependability: Expected impact to the cost of increasing the dependability of renewable sources compared to other energy storage technologies.
- Load Leveling: Expected impact to leveling out load when a NoLESS is installed to address load surges and sags.
- Carbon-Emitting Generation Reduction: Expected amount of carbon emitting generation a NoLESS can replace when used with renewable generation.

Background, Previous Projects and Technology Trends

The following documents explore the need for deploying energy storage to perform energy buffering, and the different types of energy storage technologies that are appropriate for it.

References

1) *Pathway 2045.* Southern California Edison, last modified Nov. 2019, accessed July 2022. https://download.newsroom.edison.com/create_memory_file/?f_id=5dc0be0b2cfa c24b300fe4ca&content_verified=True
2) *Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California.* National Renewable Energy Laboratory, last modified August 2016, accessed July 2022. https://www.nrel.gov/docs/fy16osti/66595.pdf
3) *USAID Grid-Scale Energy Storage Technologies Primer.* National Renewable Energy Laboratory, last modified July 2021, accessed July 2022. https://www.nrel.gov/docs /fy21osti/76097.pdf

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include the following:

Grid Operators: will have greater flexibility and an additional tool to reduce the impact of intermittent renewable generation and load while performing their duties maintaining the grid.

Ratepayers: will benefit from cleaner, more distributed energy, while experiencing fewer impacts to reliability and affordability from these new resources.

Guiding Principles

The following are the guiding principles of this Research Topic:

1) **Safety:** Many LDES technologies use materials less susceptible to thermal runaway than traditional lithium-ion energy storage technologies. LDES technologies have other safety considerations and can potentially be installed at deployment sites that lithium-ion energy storage technologies normally would not be considered for due to fire risk.
2) **Reliability:** Energy Buffering can be used to address seasonal shortfalls in renewable generation and to smooth out intermittent renewable generation and load, especially as traditional reliable forms are generation are decommissioned, and more intermittent renewable generation is installed in the state.
3) **Affordability:** Many LDES technologies are projected to be more cost-effective than lithium-ion energy storage technologies for >10 hour systems.
4) **Environmental Sustainability:** Many LDES technologies consist of materials that are more abundant and less toxic than traditional lithium-ion energy storage technologies.

Mapping of the planned investments to the electricity system value chain, which includes:

Table 13 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 13: **Energy Buffering Topic Mapping to the Electricity System Value Chain**

Electricity Value Chain	Interaction
i. Grid operations/market design	
ii. Generation	
iii. Transmission	X
iv. Distribution	X
v. Demand-side management	X

Research Topic: Bidirectional Power Flow

Innovation Need

The electric grid was originally built to deliver electricity in one direction—from power sources directly to customers. As DER adoption increases, the system needs to evolve to allow bi-directional power flows with decentralized control. This would help utilities leverage DERs to manage peak-demand, support the broader grid, and provide financial savings to customers. This topic will support the evolution of the grid to prepare for increased reverse power flows and to help realize these DER capabilities.

Topic Description

This topic aims to understand the challenges bi-directional power flows impose on both the distribution and sub-transmission systems, as well as the impacts of increasing amounts of DERs on the monitoring, protection, and control systems—systems designed for traditional, radial operation. SCE has divided this examination into four areas:

1. Identify grid assets that can support bi-directional power flow.
2. Investigate each representative area to determine assets that experience (or will experience) reverse power flow to identify which ones need to support bi-directional power flow.

3. Evaluate the protection systems and adapt innovative technologies to consider DERs in planning and operation to enhance the grid flexibility, reliability, and safety.
4. Simulate, test, and demonstrate the bi-directional power flow related technologies to evaluate the effectiveness of these technologies' performance and reliability on the grid.

In the first area, SCE plans to evaluate areas with higher levels of DER penetration, as well as grid assets that are experiencing reverse power flow. In the second area, further detailed engineering assessments will be conducted for each asset that experiences reverse power flow to determine what level of scope will be needed for each of these assets. The third area will investigate the protection challenges introduced by DERs and the plan to upgrade the substation protection system. Planning and operation of substation and distribution automation technologies also consider the presence of the DERs. In the fourth area, SCE will validate the effectiveness of the upgraded protection systems and innovative technologies in the presence of the DERs. While the topic is envisioned to be completed sequentially, work can often be conducted in parallel, and a given project may span multiple areas of examination.

Expected Outcomes

This Research Topic is intended to provide:

1. Understanding of current grid needs with respect to existing (or forecasted) bi-directional power flow.
2. Identification of challenges for substations' upgraded protection systems and grid management systems in the presence of DERs.
3. Understanding of emerging technology capabilities with respect to bi-directional power flow.
4. Lab demo to validate the functionality of the upgraded substation protection systems and grid management systems with innovative technologies in enhancing SCE's grid safety, reliability, and flexibility.
5. Recommended use cases and equipment requirements for bi-directional power flow technologies for substations and the distribution system.
6. Report on changes that should be applied to the grid and substation protection systems to handle bi-directional power flow.
7. Increased ability to take advantage of DER planning and operation purposes.

Metrics and Performance Indicators

Advancements in this Research Topic could drive improvements in the following metrics:

1. Reduce cost of day-ahead planning on the distribution system by considering the forecasted DER generation and load
2. Fewer DER curtailments
3. Increased DER hosting capacity
4. Improved reliability and safety through enhanced protection capabilities at the substation and throughout the network to isolate faults, such as during high DER generation scenarios when fault current may be reduced (due to fault current contribution of the DERs) preventing the fault from being detected and isolated quickly

Background, Previous Projects and Technology Trends

SCE's distribution system is radial in that power flows in one direction from the source (generation) to customer loads. However, increased quantities of DERs have the potential for bi-directional power flows. Prior research has been conducted on the challenges of DERs to existing protection systems. These challenges include the potential for overvoltage and overloading of a circuit. A new Coupling Relay (CR) approach has been discussed that can sense the negative sequence voltage and current. The operating conflicts in the distribution network in the presence of DG/DERs dealing with overcurrent protection, instantaneous reclose, ferro resonance, etc., as well as the changes that are needed for active distribution networks to protect against both momentary and permanent faults have been discussed. PNNL has published a report on evolving from radial to bidirectional power flow for distribution systems and microgrids. In this report a summary of the state-of-art for protecting radial distribution networks and microgrids, gaps, and the near-term solutions have been discussed. Additional previous research also includes the different applications of DERMS to optimize the power flow in active distribution networks and increase the overall distribution system efficiency.

References

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2) R. Dugan, T. McDermott, "Operating Conflicts for Distributed Generation on Distribution Systems," IEEE 2001 Rural Electric Power Conference.
3) McDermott, T. E., Fan, R., Thekkumparambath Mana, P., Vyakaranam, B. G., Smith, T., Hambrick, J., … & Barnes, A. (2019). Relaying for distribution and microgrids evolving from radial to bidirectional power flow (No. PNNL-29145). Pacific Northwest National Lab.(PNNL), Richland, WA (United States).
4) N. Petrovic, L. Strezoski and B. Dumni", "Overview of software tools for integration and active management of high penetration of DERs in emerging distribution networks" IEEE EUROCON 2019 -18th International Conference on Smart Technologies, 2019, pp. 1-6, doi: 10.1109/EUROCON.2019.8861765.

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include the following:

Customers: benefit from a more flexible, reliable, and cost-effective electric grid.

Distribution planners: benefit from the results of this topic in terms of improved understanding of the implications of the forecast of DER generation and having the means to address bi-directional power flows.

Grid Operators: benefit from having the grid management capabilities that accommodate bi-directional power flows.

Guiding Principles

The following are the guiding principles of this Research Topic:

1) **Safety:** By demonstrating that certain grid assets and protection schemes need to be upgraded for safer operation.
2) **Reliability:** By improving the protection capabilities and grid management functionalities to detect the accurate fault location, isolate the faulted area, and restore as many interrupted customers as quickly as possible.

3) **Affordability:** By allowing customers to more fully benefit from DER generation through energy exports to the grid.
4) **Environmental Sustainability:** By enabling higher DER penetration and reducing the reliance on fossil fuel power plants.
5) **Improving Equity:** By encouraging and securing the adoption of innovative technologies for both substation and grid advancement in under-resourced communities.

Mapping of the planned investments to the electricity system value chain, which includes:
Table 14 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 14: Bi-directional Power Flow Topic Mapping to the Electricity System Value Chain

Electricity System Value Chain	Interaction
i. Grid operations/market design	
ii. Generation	
iii. Transmission	
iv. Distribution	X
v. Demand-side management	X

Research Topic: Islanding & Reconfigurability

Innovation Need

Microgrids have the ability to "island," which allows microgrid customers to remain energized through planned and unplanned outages. A conventional microgrid manages generation and demand behind a single point of common coupling—the point where the microgrid connects with the broader grid. These microgrids focus on operation using a single centralized resource to take the responsibility of maintaining grid stability in islanded operation, which typically requires a large, upfront investment and only benefits a small pre-determined location. Currently, microgrids only benefit those who can afford this large upfront investment. To enhance the value proposition of microgrids and DERs, the benefits need to be expanded to a broader base of customers. Additionally, DERs with features such as grid forming inverters and frequency and voltage support are beginning to enter the market. These smart DERs create an opportunity to change islanding boundaries but will require advanced and decentralized control to manage the resources. Achieving the system-wide microgrid benefits of reliability and resiliency on an equitable basis will require the ability to dynamically island and reconfigure the microgrid area.

Topic Description

As the penetration of smart DER resources increases, advanced decentralized control is required for managing resources to meet both resiliency and reliability needs by creating reconfigurable boundaries. With the formation of self-sustainable islands, the control system will increase the utilization of third-party or customer DER resources, which would otherwise be offline during outages.

This Research Topic looks to combine distributed and aggregated DER and distributed intelligent controllers in a new approach to microgrid operations during island and non-island operation. Advanced microgrids will have various DER technologies, ownership models (utility owned, customer/third-party owned) and operating models. An adaptive nested architecture model will be created to evaluate the scalability of a microgrid from a site controller, to a partial circuit, to a full circuit and full substation controller with multiple-points-of-common-coupling (MPCC). Realization of advanced resilient microgrids requires the ability to dynamically reconfigure island sections, decentralized control, and low latency communication. Depending upon the size of load block, nature of the distribution line, availability and types of DERs, and communication network, a microgrid could island, reconnect and reconfigure seamlessly.

The topic plans to leverage the projects from other topics within this Investment Plan, particularly Adaptive Protection, Ultra Low-latency Communications and Seamless Grid Flexibility. The advanced microgrid controller will integrate with other advanced applications or capabilities such as adaptive protection, automated feeder reconfiguration and fault location, isolation and service restoration (FLISR) of SCE's new Grid Management System (GMS) to create seamless reconfigurable electrical boundaries of the microgrid islands.

The decentralized architecture of these microgrid islands will need to be cybersecure with fail-safe capabilities to be functional during loss of communication with the centralized grid management system. These capabilities would require resilient and ultra-low latency, peer-to-peer communication systems between the islanded resources and the edge controls (i.e., communications would still be possible between islanded resources and SCE field devices despite loss of communications with back-office systems). A digital twin system could be developed to simulate, test, and demonstrate different communication, control, protection, and reconfiguration schemes in the hardware-in-the-loop test bed. The digital twin environment would help compare different centralized and decentralized communication and control systems to identify requirements, advantages, disadvantages for microgrids and islanding applications.

Expected Outcomes

This Research Topic is intended to provide:

- Validation of integration of advanced microgrid controller with applications/capabilities such as adaptive protection, automated feeder reconfiguration and FLISR to seamlessly create reconfigurable electrical boundaries of the microgrid islands.
- Development of digital twin environments for testing and validating different communication, control, protection, and reconfiguration schemes.
- Identification of technical requirements and cost benefit analyses of centralized and decentralized communication and control systems.

Metrics and Performance Indicators

The islanding and reconfigurability topic will use a digital twin and hardware in the loop test bed to demonstrate the functionality and benefits of a re-configurable microgrid. Success and performance will be measured by:

- Improvements in reliability and resilience metrics (SAIDI, SAIFI, CMI, etc.) for a circuit with and without reconfigurable microgrids
- Cost benefit analyses of reconfigurable versus static microgrids
- Simulated cost savings in distribution system upgrades (e.g., when a microgrid can help to defer or avoid a traditional wires investment)
- Increase in number of DACs covered by resiliency

- Increase in Community Resiliency Metric (CRM) used in SCE's Climate Adaptation Vulnerability Assessment (CAVA)

Background, Previous Projects and Technology Trends

The general concept of microgrids have been proven and this topic builds on and complements SCE's EPIC 3microgrid projects: Smart City Demonstration, Service and Distribution Centers of the Future, and Control and Protection for Microgrids and Virtual Power Plants. Furthermore, the Commission has recently initiated R.19- 09-009 to begin crafting a policy framework surrounding the commercialization of microgrids.

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include the following:

Utilities: such as SCE can utilize the project for distribution system operations and planning. The flexibility provided by microgrids can lead to more rapid and economic deployment of resilient systems.
Customers: benefit from improved reliability and resiliency, which is dispersed more equitably First Responders will benefit from reduced impact of system outages.

Guiding Principles

The following are the guiding principles of this Research Topic:

1) **Safety:** Reducing the impact and duration of outages reduces the safety risk associated with loss of power.
2) **Reliability:** Improving the ability to adapt to system faults and maintain customer power during outages would improve reliability and resiliency.
3) **Affordability:** Adaptability of grid configuration could improve affordability of resiliency efforts.
4) **Environmental Sustainability:** Improving the utilization of DERs will incentivize the adoption of more clean energy resources.
5) **Improving Equity:** Reducing the upfront cost of resiliency can improve the equity of system reliability.

Mapping of the planned investments to the electricity system value chain, which includes:

Table 15 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 15: Islanding & Reconfigurability Topic Mapping to the Electricity System Value Chain

Electricity System Value Chain	Interaction
i. Grid operations/market design	X
ii. Generation	
iii. Transmission	
iv. Distribution	X
v. Demand-side management	

VIII. Strategic Objective C: Inform California's Transition to an Equitable, Zero-Carbon Energy System that is Climate-Resilient and Meets Environmental Goals

As California transitions to an equitable, zero-carbon energy system, utilities will require new approaches to energy system planning. Achieving a climate-resilient and reliable grid that is sufficiently flexible and adaptable to our changing climate and increasing environmental hazards (e.g., extreme heat and wildfire threats) requires new methods of system analysis. Many of the traditional power system analysis methodologies depend on the more traditional model of centralized generation output distributed via one way power flows to the customer. In addition, current grid planning processes are based on historical data, which is no longer adequate in the face of climate change. Finally, further electrification of the energy system will place new demands on the grid. Utilities will need to perform a more integrated analysis of the T&D system as one integrated system for planning and operations, taking into account how climate and energy use will continue to evolve. As new technologies capable of addressing these challenges are commercialized, they need to be thoroughly tested in a "safe" environment that does not unduly impact customers.

Under Strategic Objective C, SCE will pursue the following two Strategic Initiatives:

- Vulnerabilities, Threats, and Hazard Reduction
- Digital Transformation

Strategic Initiative: Vulnerabilities, Threats, and Hazard Reduction

The changing climate has increased environmental hazards to the electric system and our customer communities. Better assessment of these environmental hazards and new approaches to grid hardening could mitigate the impacts of these environmental threats, such as contact with vegetation, flying debris in a storm, earthquakes, mud slides, mud flows, floods, fires, and electromagnetic pulse (EMP) activity.

SCE proposes the following Research Topics:

- Hardening and Remediation
- Safety and Work Methods Advancement

Research Topic: Hardening and Remediation

Innovation Need

The grid is constantly affected by external factors, such as extreme weather events from climate change, vehicles inadvertently hitting assets, and cyber-attacks, to name a few. Reducing the risks posed by these external factors by increasing the resilience of the grid is key to ensuring a reliable and sustainable electric system. Currently, wildfire mitigation efforts often rely on PSPS, which creates hardships for customers. Innovation is therefore urgently needed to bring new resilience technologies to the grid in response to physical and cyber threats. In addition, cyber-attacks are increasing in frequency and as the grid uses more communication networks and cloud computing processes, we must assess how these attacks impact the operation, health, and resilience of the grid, and identify appropriate mitigations.

Topic Description

This topic will demonstrate technologies that can reduce the need for or impact of PSPS and/or other man-made or natural disasters through new and alternative methods. Areas of investigation will include:

1) Hardening the grid, such as increased sectionalizing devices
2) Reducing grid exposure to wildfires and weather-related events
3) Improving situational awareness with distributed sensors
4) Deploying new technology to restore power

These efforts include new sensing and detection technology for identifying potential grid faults before they occur and improving the situational awareness of the grid in real-time. This topic will also examine new construction methods and hardware to make undergrounding technically, financially, and logistically feasible. Furthermore, we will demonstrate technologies that help the grid remain resilient even after PSPS is triggered. The intent is for these technologies to help ensure that customers in a PSPS zone, but not directly in the path of the wildfire, remain energized.

Expected Outcomes

One or more technologies will be demonstrated to evaluate their feasibility and potential effectiveness in improving the resiliency of SCE's existing and new infrastructure. A priority will be given to technologies that help utilities reduce the risks from climate-related events and other external threats that could obviate PSPS events or reduce the impacts of PSPS events.

Metrics and Performance Indicators

Advancements in this Research Topic could drive improvements in the following metrics:

1) Reduced number of customers impacted by PSPS events
2) Reduced ignition risk by limiting contact from object risks
3) Increased reliability (lower SAIDI and SAIFI)
4) Reduced number of PSPS events
5) Reduced time to identify fault with new patrol/sensing methods

Background, Previous Projects and Technology Trends

Numerous studies have been conducted on how climate impacts have resulted in an increased number of wildfires. In particular, utility-caused fires have resulted in catastrophic fires in remote locations. Climate and weather changes have increased wildfire risk along with the associated drought (pre-fire) and flooding (post-fire). To the extent these risks impact DACs more frequently than average, improvements in mitigating these risks would help improve equity.

References:

1) Mitchell, J. W. (2013). "Power line failures and catastrophic wildfires under extreme weather conditions." Engineering Failure Analysis 35: 726-735
2) Approximately 16% of the utility ignition fires that burned more than 10 acres between 2014-2018 were known to be caused by contact with vegetation; while 32% of the utility ignition fires causing more than ten acres to burn between 2014-2018 were caused by equipment failures. https://energysafety.ca.gov/wp-content/uploads/docs/strategic-roadmap/final_report_wildfiremitigationstrategy_wsd.pdf#%5B%7B%22num%22%3A388%2C%22gen%22%3A0%7D%2C%7B%22name%22%3A%22Fit%22%7D%5D, p. 18. (See Appendix B)
3) Syphard, A. D. and J. E. Keeley (2015). "Location, timing and extent of wildfire vary by cause of ignition." International Journal of Wildland Fire http://dx.doi.org/10.1071/WF14024.
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5) National Significant Wildland Fire Potential Outlook, Predictive Services, National Interagency Fire Center, Outlook Period March-June 2022, Executive Summary, p. 2, https://www.predictiveservices.nifc.gov/outlooks/monthly_seasonal_outlook.pdf
6) California Investor Owned Utility Wildfire Mitigation Plans. https://energysafety.ca.gov/what-we-do/electrical-infrastructure-safety/wildfire-mitigation-and-safety/wildfire-mitigation-plans/

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include:

Customers: will experience fewer outages from PSPS events, providing convenience and cost savings from avoiding these events.
Operators: a more resilient grid will reduce the need for calling and managing PSPS events.

Guiding Principles

The following are the guiding principles of this Research Topic:

1) **Safety:** Customer and worker safety will be improved by grid hardening, which mitigates risks posed by utility assets such live down wires and arcing conditions.
2) **Resiliency:** Hardening grid assets such that they remain in service during unpredictable events such as wildfires or earthquakes would improve grid resilience.
3) **Reliability**: Grid hardening will also improve customer reliability (SAIDI/SAIFI) since fewer customers would be impacted by outages and there would be a reduced need for PSPS events.
4) **Environmental Sustainability**: A hardened grid will help reduce ignitions induced by high-voltage equipment and help to prevent hardened grid assets from burning down during a wildfire. By reducing ignitions (and the loss of grid infrastructure due to wildfires), the chemicals and smoke resulting from burning forests and equipment will be reduced.

Mapping of the planned investments to the electricity system value chain, which includes:
Table 16 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 16: Hardening and Remediation Topic Mapping to the Electricity System Value Chain

Electricity Value Chain	Interaction
i. Grid operations/market design	
ii. Generation	
iii. Transmission	X
iv. Distribution	X
v. Demand-side management	

Research Topic: Safety and Work Methods Advancement

Innovation Need
The amount of work required to maintain the electric grid has increased significantly in recent years, as the useful life of our grid assets nears the end, and field workers are experiencing more risks and challenges in performing their daily tasks. Factors that increasingly affect field workers include extreme weather conditions, fatigue, and location-specific risks of the work area. Innovation is needed to mitigate the impact of these factors on field workers and to potentially create efficiencies in their tasks. As the workload increases, field workers will need tools and work methods to increase the safety and efficiency of their work.

Topic Description
This topic will demonstrate technologies designed to improve the safety of both company personnel and the public. The use of sensors and intelligence on the edge of the system is expected to enable new, safer work methods, increase work efficiencies, and provide cost savings. We will demonstrate technologies that enable field workers to maintain a safe environment, manage proper health metrics (hydration, fatigue), and perform field tasks effectively.

Expected Outcomes
This topic plans to demonstrate technologies that make field workers effective and safe while performing work in the field. Evaluations in this topic include:
- Demonstration results of new tools, technologies and techniques used to optimize work processes.
- Demonstration results of technologies used to create a more digitized, efficient, and safer environment for field personnel.
- Demonstration results of technologies to evaluate field worker status for performing work duties safely.
- Increase overall public and worker safety.

Metrics and Performance Indicators
Advancements in this Research Topic could drive improvements in the following metrics:
- Reduction in number of reportable field incidents.
- Reduction in in Days Away Restricted Duty (DART) incident rate.
- Elimination of well-known risks and inefficiencies in the field.

Background, Previous Projects and Technology Trends

SCE's EPIC 2 Proactive Storm Impact Analysis Demonstration Project was designed to demonstrate improved operational efficiency and cost reductions associated with storm-related outages through enhanced data analytics and forecasting capabilities using machine learning. Based on the results and learnings from the project, SCE is better prepared to react to more extreme weather events from climate change. Additionally, our EPIC 3 project, Augmented Reality for Safety and Efficiency is underway to leverage augmented reality and machine learning to improve worker and efficiency safety in the field.

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include the following:

7) **Field Crews:** Leverage technology to perform work more safely and with better quality.
- **Planners:** Leverage technology to stay safe when visiting the field and to obtain the proper information in the field to make more informed decisions.
- **Field Inspectors:** Leverage technology to stay safe when visiting the field and to obtain the proper information in the field to make more informed decisions.
- **Emergency Response teams:** Leverage technology to stay safe when visiting the field and to obtain the proper information in the field to make more informed decisions.

Guiding Principles

The following are the guiding principles of this Research Topic:

1) **Safety:** Field crew safety will be demonstrated using technology to detect hazardous situations and warn employees of such hazards. Such hazards could be due to the environment or to invisible risks posed by the electric grid equipment. Finally, real-time analysis of the health/state of field workers while in the field helps to ensure proper measures are taken to mitigate the risk of worker fatigue, dehydration, etc.
2) **Reliability:** This topic supports increased reliability by improving work methods – such that worker mistakes do not result in unplanned outages (or extend planned outages). Real-time monitoring of field worker health and focus can also be leveraged to demonstrate quality control of the field work being executed.

Mapping of the planned investments to the electricity system value chain, which includes:

Table 17 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 17: Safety and Work Methods Advancement Topic Mapping to the Electricity System Value Chain

Electricity Value Chain	Interaction
i. Grid operations/market design	
ii. Generation	
iii. Transmission	X
iv. Distribution	X
v. Demand-side management	

Strategic Initiative: Digital Transformation

Achieving a more reliable, resilient and equitable electric grid necessitates the digitization of more utility data and processes. As emerging technologies (customer and grid asset) are integrated with the grid in vastly higher numbers (i.e., millions of devices), digitizing data and processes is critical to providing situational awareness for grid operators to optimize these assets and mitigate threats from climate change. SCE proposes the following Research Topics:

- Data-driven Operations
- End-End Advanced Simulation and Analytics

Research Topic: Data-driven Operations

Innovation Need

Climate-related events can occur quickly, introducing immediate hazards to the electric grid. These uncertainties can impact the effectiveness of grid operator responses. Understanding the impacts of climate change to the electric grid is critical to engineering remediation designs and having acute real-time situational awareness to support operational decisions. Additionally, timely capture and analysis of electric asset data is important for making informed decisions—decisions about current operations and events, and future system planning. Existing and future technologies will generate large amounts of data that need to be analyzed to support optimal grid operations decisions. There is therefore a need to innovate how data is collected, structured and aligned most effectively. As utilities perform grid resilience upgrades to adapt to climate change, capturing accurate data using new methodologies and innovations that improve situational awareness is essential to making informed decisions for the electric grid operations and planning.

Topic Description

This topic will examine the blending of traditional grid simulation and analytics methodologies, environmental data, and machine learning techniques to evaluate how to combine and use this information to enhance grid planning, operations, and maintenance. Use of big data applications within a digital twin environment[41] will be critical to achieving the expected outcomes for this topic.

Expected Outcomes

This Research Topic is expected to result in technology that helps identify, collect, organize, process, and visualize data to assist various stakeholders in making better-informed real-time decisions. SCE plans to demonstrate the following:

- Technologies for collection of key data that improves the effectiveness of real-time operations.
- Integration of large and disparate data sets and systems.
- Automatic processing of large datasets for planning and real-time operational insights.
- Use of various datasets and machine learning to develop key insights.
- Technology that creates effective visualization and user interfaces that optimize the real-time decisions of grid operations.

Metrics and Performance Indicators

Advancements in this Research Topic could drive improvements in the following metrics:

[41] The digital twin is part of the Islanding & Reconfigurability Research Topic.

- Reduce amount of data needed to be communicated to the back-office (i.e., Grid Edge processing)
- Reduce time for changes made in the field to be reflected on the digital record of the grid.
- Faster grid operator response time to real-time events

Background, Previous Projects and Technology Trends

SCE has collected large amounts of data as part of its Wildfire Mitigation Program especially in the areas of aerial and ground imagery through its enhanced detailed inspection programs. These inspection programs require new ways to approach utility data management. New platforms, such as drones, have proven to improve the quality of data capture and unlocked new questions, such as how to manage large data sets. Street-level image capture has opened up another key capability in terms of correcting utility asset geolocations for planning purposes. Remote sensing data from drone, helicopter, and satellite data has the potential to reduce vegetation management costs through an Integrated Vegetation Management solution.

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2) How Utilities Can Use Drone, Helicopter, and Satellite Data as Part of an Integrated Vegetation Management Solution, Geoawesomeness, https://geoawesomeness.com/eo-hub/how-utilities-can-use-drone-helicopter-and-satellite-data-as-part-of-an-integrated-vegetation-management-solution/

Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include the following:

Field Engineers: Leverage historical data, real-time data, tools and technology to troubleshoot field issues and develop appropriate mitigation plans.

Wildfire Incident Management Team: Obtain relevant and critical real-time data and insights through user-friendly tools to make data-informed decisions in real-time.

Protection Engineers: Leverage grid data and model to improve protection settings.

Power System Operators / Operation Engineers: Leverage real-time data, contextual data, insights, tools and technology to make optimal grid operations decisions.

Guiding Principles

The following are the guiding principles of this Research Topic:

1) **Safety:** Grid operations decisions based on real-time data (and insights) will help to prevent mis-operations such as energizing systems being worked on in the field.
2) **Reliability:** Grid operations decisions based on real-time data (and insights) will promote system reliability.
3) **Resiliency:** Grid operations decisions based on real-time data (and insights) will help to promote grid resilience.

Mapping of the planned investments to the electricity system value chain, which includes:
Table 18 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 18 Data-driven Operations Topic Mapping to the Electricity System Value Chain

Electricity Value Chain	Interaction
i. Grid operations/market design	X
ii. Generation	
iii. Transmission	X
iv. Distribution	X
v. Demand-side management	

Research Topic: End-to-end Advanced Simulations and Analytics

Innovation Need
The operational complexity of the electric grid is accelerating due to the increasing amounts of distributed intermittent generation at all voltage levels, such as EVs and other battery storage technologies. In the future, the grid will be characterized by bi-directional power flows across the system—in contrast to how energy has traditionally flowed in one direction from an upstream, high-voltage generation source down to customer loads. Two-way power flows present reliability and resilience challenges to system planners and operators. Additionally, system instability and lack of inertia, introduced by high amounts of inverter-based resources such as DERs, necessitates evaluating how the distribution and transmission systems interact with and affect each other.

In addition to the fundamental change in the grid architecture from DERs, the grid faces persistent challenges from external factors out of SCE's control such as weather, climate, societal, and customer demand behaviors. The data from such events needs to be captured to support learning to help operators and engineers best plan for similar events in the future.

Utilities need comprehensive simulation capabilities to adequately plan for various scenarios in which inverter-based resources become the dominant source of generation and load. Furthermore, unpredictable events can only be planned for and mitigated if the proper historical data, real-time contextual data, external prediction models and data, and tools are available to perform and interpret future simulations. Once these simulations are performed and reviewed, we can then properly identify solutions for maintaining grid reliability and resiliency in the future.

Topic Description
This Research Topic aims to demonstrate the following:

1. Software tools to help planners conduct end-to-end electric grid simulations. The objective will be to perform scenario analysis across both transmission and distribution systems.
2. Tools to help predict future behavior using machine learning instead of deterministic models and assumptions. This approach differs from conventional planning tools since it uses historical data and context to find trends to make predictions.
3. The ability to process extremely large amounts of data efficiently and timely. As the number of assets on the grid grows and use of electrical energy expands, the amount of data generated will

grow exponentially. We must therefore demonstrate the scalability of our tools to handle the expected increase in data volume.

4. Software tools to help grid operators prepare their responses to future events such as natural disasters and cyberattacks. Responses to these events can be simulated using tools that display the impact of any operation on both the distribution and transmission systems.

Expected Outcomes

This Research Topic is expected improve SCE's planning for increased grid operating complexity and its ability to respond to unforeseen events through advanced end-to-end simulation and machine learning. SCE plans to demonstrate the following:

1. Testing of emergency response processes for various scenarios, potentially including process optimization to minimize overall reliability and resiliency impacts. The goal is to help plan for various events that could threaten grid security, resiliency and reliability.
2. Planning of optimal placement of assets throughout the system to address various challenges, while ensuring system stability, resiliency and reliability.
3. Scenario analysis for an inverter-based, resources-dominant grid, including identification of hardware and optimal control criteria to maintain system stability.
4. Scenario analysis and performance comparison against conventional deterministic models used today.
5. Comparison of error between historical field results and output from machine learning based simulation using historical input data.
6. Improved planning practices that leverage more data input for making investment decisions.

Metrics and Performance Indicators

Advancements in this Research Topic could drive improvements in the following metrics:

1. Reduced and/or optimized project costs through optimization of asset allocation and system upgrades.
2. Improved economies of scope through optimal bundling of scopes for each project based on simulation.

Background, Previous Projects and Technology Trends

The Advanced Distribution Management System (ADMS) is a current project that uses state estimation to perform simulation. However, this simulation does not currently bridge the gap between transmission and distribution. Furthermore, it does not leverage machine learning to enhance the simulation results.

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Primary Users and Beneficiaries

The primary users and beneficiaries of this Research Topic include the following:

T&D System Planners: better identify how various upgrades or changes to the system will impact the grid and improve certain metrics (e.g., capacity, reliability, etc.).

Emergency Response Team: helps to evaluate how different actions taken on the grid can affect customers and the state of the grid.

Operations: helps to identify the grid impact of potential switching operations.

Field Engineers: helps to identify how various scenarios to address field issues would impact the grid.

Protection Engineers: results help to identify how various protection settings could affect the grid.

Distribution Automation Engineers: benefit from being better able to identify how automation schemes and settings impact the grid.

Guiding Principles

The following are the guiding principles of this Research Topic:

1) **Reliability:** Simulation and prediction using a digital grid replica under various scenarios involving protection and control decisions will help protection engineers and automation engineers select proper schemes that maximize reliability in every scenario.
2) **Affordability:** Simulation using a context-rich model will enable planners to identify and optimize their grid enhancements planning decisions.
3) **Resiliency:** Simulating and predicting grid resiliency responses to various grid scenarios using real-time data, historical data, third party models, and context will result in operations and planning decisions that optimize resiliency.

Mapping of the planned investments to the electricity system value chain, which includes:

Table 19 summarizes the mapping of this Research Topic to the electricity system value chain.

Table 19 End-to-end Advanced Simulations and Analytics Topic Mapping to the Electricity System Value Chain

Electricity Value Chain	Interaction
i. Grid operations/market design	X
ii. Generation	
iii. Transmission	X
iv. Distribution	X
v. Demand-side management	

IX. Program Administration

SCE's EPIC administration is composed of the following aspects:

- Program outreach efforts
- Portfolio management
- Knowledge sharing and lessons learned
- Benefits metrics and evaluation

Furthermore, equity is embedded throughout SCE's approach to administering the EPIC Program.

Program Outreach Efforts

Stakeholder feedback on SCE's proposed EPIC 4 Plan and projects is vital to help develop robust solutions for key opportunities and challenges facing the grid. As discussed in the Summary of Stakeholder Engagement Section,[42] the joint Utilities conducted extensive stakeholder outreach to better inform and enhance their EPIC 4 Investment Plans. SCE consults with the following types of stakeholders through EPIC public workshops during the development and administration of SCE's EPIC 4 Plan:

- Utilities
- California Independent System Operator (CAISO)
- Community-based organizations
- Consumer groups
- Environmental organizations
- Agricultural organizations
- Academic experts
- Business community
- Energy efficiency community
- Clean energy industry associations

To support the development of the Utilities' respective EPIC 4 Investment Plans, four joint workshops were held by the Utilities, including two workshops that specifically targeted disadvantaged and vulnerable communities. Additionally, the joint Utilities presented their respective EPIC 4 Investment Plans to the DACAG for feedback.

[42] *See* p. 7.

SCE coordinates with the CEC and participates in the EPIC Symposium on an annual basis. The EPIC Symposium showcases the four program administrators' (CEC and the Utilities) work. The EPIC Symposium informs and engages a wide array of stakeholders on SCE's demonstrations and the value these projects bring to customers.

SCE leads tours of its innovation labs to highlight EPIC technologies being evaluated to better inform utility regulators and potential Utilities considering adopting these technologies.

Portfolio Management

SCE intends to manage its EPIC 4 Portfolio according to the Commission's approval of its Strategic Objectives, Strategic Initiatives and Research Topics. Following Commission approval, SCE will determine which Strategic Initiatives to address first and obtain internal management approval to proceed with planning and spending the authorized funding for supporting projects.

Once projects have been scoped, SCE will follow the Commission's requirement to hold a public workshop 30 days prior to initiating the project. At these public EPIC 4 project workshops, SCE will provide an overview of the project, describe the proposed technologies to be evaluated,[43] and discuss the anticipated benefits. SCE welcomes stakeholder feedback, especially from disadvantaged and vulnerable community members, on how to better include specific opportunities and challenges facing these communities into EPIC 4 projects. Importantly, at these EPIC 4 project workshops, SCE will provide information to stakeholders on project procurement opportunities, especially to small and diverse businesses that help serve local southern California communities. EPIC projects often have multiple procurement opportunities that occur throughout the duration of a project.

SCE plans to continue following the Commission's EPIC Intellectual Property (IP) requirements that were outlined in D.13-11-025. To increase cost sharing opportunities with research partners, such as national labs, SCE requests the Commission clarify IP terms of infringement and march-in rights. SCE specifically requests the Commission clarify the following:

- Indemnification is limited to infringement and not unbounded liability on the part of the participant partner.
- March-in rights are allocated to the Federal Government and not California in cases where the Program Administrator is collaborating with national labs.

SCE will use its allocated program administration budget, consistent with the 10% administrative cost cap.[44] Furthermore, SCE intends to manage its administrative budget according to the Commission's approved joint administrative framework, included as Appendix D.

Knowledge Sharing and Lessons Learned

SCE regularly shares knowledge and lessons learned from its EPIC demonstrations to interested stakeholders and the electric utility industry. The sharing of results helps to increase utilities' adoption of emerging technologies to enhance the grid and in doing so, helps to advance industry standards. SCE shares information with its fellow program administrators (PG&E, SDG&E and the CEC) through coordinated deep-dive discussions with CPUC staff, topic-specific meetings to better learn of

[43] Including any financial incentives to customers as part of the project.
[44] D.21-11-028 at p. 35.

Administrators' projects, and joint public workshops. Additionally, results are also shared through the following mechanisms:

- SCE posts project final reports to its website[45] of completed demonstration projects. These final reports provide an overview of the project and discuss the issue or problem addressed, demonstration, analysis and findings. For technologies successfully demonstrated, recommendations are included for the next steps for these technologies.
- SCE regularly participates in technical conferences and presents on EPIC projects.
- The CPUC, through the Policy + Innovation Coordination Group (PICG), has developed a database of all the EPIC Administrators projects. The PICG EPIC database provides better visibility to all EPIC projects.
- SCE's EPIC website[46] provides information to the public on SCE's administration of EPIC, including past workshop presentations, investment plans, and final project reports. SCE welcomes continuous feedback from stakeholders on emerging technologies and innovative solutions to advance the grid in EPIC. SCE's website provides contact information and links, such as https://www.sceideas.com to provide direct feedback.

Benefits Metrics & Evaluation

For each proposed Research Topic, SCE has included expected outcomes and high-level metrics and performance indicators. SCE plans to assess these metrics throughout the implementation of each project supporting the proposed Research Topics.

The metrics and performance indicators help SCE evaluate anticipated and realized project benefits. Benefits expected to result from demonstration of pre-commercial technologies include:

- Validating technologies in a laboratory setting
- Validating technology performance, including reliability and safety, in the field
- Identifying and overcoming challenges for further deployment

SCE tracks EPIC program- and project-level metrics. At the program level, through annual reporting requirements, SCE tracks the following metrics:

- Technologies that directly and indirectly contribute to further deployment of technologies through the General Rate Case
- Projects that help advance industry standards
- Industry conference presentations and publications on EPIC projects
- Procurement opportunities for small, diverse businesses

SCE also tracks both potential and realized project-level benefits. SCE evaluates potential projects based on both the potential quantitative and qualitative benefits of a project, compared to what may have happened if SCE did not conduct the demonstration. In D.13-11-025, the Commission approved a list of benefits and allows the opportunity to create new, project-specific benefits metrics.[47] SCE intends to

[45] https://www.sce.com/regulatory

[46] *Ibid*.

[47] D.13-11-025, Attachment 4.

leverage this list to create qualitative and quantitative metrics to evaluate potential benefits of each EPIC 4 project.

X. Conclusion and Next Steps

The Strategic Initiatives SCE presents in its EPIC 4 Investment Plan will help to enable SCE's vision for the future of the electric grid, providing leadership and innovation in addressing climate adaptation and further enabling a high-DER future, and helping California to achieve its energy and environmental policy goals, while also supporting key Commission proceedings. Moreover, SCE developed its EPIC 4 plan to enhance equity, so that all customers benefit from advancements to the electric grid. SCE gained valuable stakeholder input through the two public Workshops and two DAC-targeted Workshops. The extensive stakeholder input from these Workshops helped shape the Strategic Initiatives proposed in this EPIC 4 Investment Plan.

SCE anticipates the Commission will review and consider for approval the Utilities' EPIC 4 Applications during the fourth quarter of 2022 and issue a final decision by year-end. If SCE's EPIC 4 Investment Plan Application is approved by the Commission, SCE will develop projects under the initiatives identified in this plan and hold project workshops to seek stakeholder feedback. SCE looks forward to continued collaboration with the Commission and other EPIC stakeholders to pursue electric grid advancements that deliver value to our customers and broader California community.

XI. Appendices

A. Benefits Impacts Report

B. Acronyms and Abbreviations

C. Stakeholder Engagement

D. Summary of Emerging Technology projects from latest demand response projects

Appendix A

Benefits Impacts Report

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Southern California Edison Company's Benefits Impact Report
Submitted in compliance with D.21-11-028
October 3, 2022

I. Executive Summary

In the California Public Utilities Commission's (Commission's) decision (D.) 21-11-028, the Commission instructed the Utilities (PG&E, SCE and SDG&E) to:

- Coordinate with the California Energy Commission (CEC) and the Commission's Energy Division staff to develop a single, uniform benefits analysis framework and set of metrics that enable the evaluation and tracking of the benefits of all EPIC projects.[1]
- File a report documenting their success to-date of the EPIC projects under its administration, using the metrics they are ordered to create in OP 12, and in working with Commission's Energy Division staff.[2]

SCE has coordinated extensively with PG&E, SDG&E, the CEC and Commission Energy Division staff to create a uniform framework for benefits analysis of all EPIC projects.

SCE's EPIC projects benefit customers by providing a means to test and evaluate the integration of pre-commercial or early commercial technologies on the electric grid. As a planner and operator of the grid, SCE's administration of EPIC supports California's energy and environmental policies and key Commission proceedings. Examples of SCE's EPIC Program successes include the following:

- SCE's *Integrated Grid Project* (EPIC 1 and 2) provided a substantial number of requirements for SCE'S new Grid Management System that is being implemented
- to replace the distribution and outage management system and introduce new distributed energy resource (DER) management capabilities.
- *Distribution Automation* projects (EPIC 1 and 2) have informed technical requirements, specifications, and product recommendations for much of the operational technology (OT) aspects of SCE's Grid Modernization program, including intelligent automated switches and grid telemetry components.
- *Substation Automation* projects (EPIC 1 and 2) have informed technical requirements for digitizing protection, automation, and control of modern substations. This work has led to more future-leaning projects, including the virtualization of protection relaying, in EPIC 3.
- The *Distributed Energy Resource Dynamics Integration Demonstration* (EPIC 3) has improved our understanding of the power system dynamics created by high DER penetration and how distribution relaying protection systems need to evolve.

II. Coordination

In D.21-11-028, the Utilities were instructed to coordinate with the CEC and Commission staff on a single, uniform benefits analysis framework and set of metrics.[3] The Utilities developed a uniform approach to track project metrics and analyze benefits. The Utilities jointly coordinated with the CEC to align and develop a single, uniform approach for project benefits. The Utilities reviewed the CEC's benefits tools and will integrate these tools into their benefits

[1] D.21-11-028, OP 12, at p. 57.
[2] *Id.*, OP 13, at p. 58.
[3] D.21-11-028, OP 12, at p. 57.

analyses for projects, where applicable. The increased coordination between the Utilities, CEC and the Commission has resulted in a more robust framework where the Utilities are able to complement the CEC's efforts with tools most appropriate for Utility demonstration projects. A detailed list of the benefits tools that were coordinated among the Utilities, CEC and Commission staff is provided in the Benefits section below.[4]

III. Benefits

In EPIC, Utilities conduct technology demonstrations to advance the capabilities of the grid. These demonstrations take place in a laboratory and/or field setting. In general, demonstrations conducted in a laboratory environment help to evaluate competing technologies and perform system testing under controlled conditions. Lab demonstrations provide the following advantages over field demonstrations:

- Environment for conducting repeatable tests to identify equipment and configurations that best fit SCE's needs
- Repeatable "events" to feed analytic applications to test the capabilities
- Data to inform vendor selection for new equipment and systems
- Identification of products and systems sufficiently developed that they could be tested under field conditions

Given the expense and longer time required to perform field demonstrations, laboratory demonstrations are much more cost-effective for obtaining insights into equipment and system behavior and determining what needs to be tested in the field. Field demonstrations are used to expose equipment and systems to real world conditions that are difficult to simulate in the laboratory. Field demonstrations also provide information on how new equipment and systems are accepted by and used by customers and employees. Field demonstrations generally provide the following advantages over lab demonstrations:

- Demonstrations occur under actual grid conditions
- Environmental conditions not possible to duplicate in the lab environment
- Feedback from customers and employees on the acceptability of the system
- Determination of whether the system is ready for deployment

SCE coordinated with PG&E, SDG&E and the CEC to align on tools to calculate EPIC demonstration benefits. Appendix A, Working Benefits Framework provides the benefits tools SCE used to assess its EPIC projects.

The benefits described in this report are divided into two main categories: EPIC Program-driven Benefits and Additional Sources of Value. *EPIC Program-driven Benefits* include the three customer benefits that define EPIC's primary and mandatory guiding principle of promoting greater reliability, lower costs, and increased safety to ratepayers. This first category also includes other complementary benefits, which include societal benefits, greenhouse gas (GHG) emissions mitigation and adaptation at the lowest possible cost, loading order, low-emission vehicles/transportation, economic development, and efficient use of ratepayer monies. *Additional Sources of Value*, the second main benefit category in this report, describes how the EPIC projects support Commission proceedings (such as the Distribution Resources Plan, Microgrid OIR, Climate Adaptation OIR, etc.), influence and stimulate the development of market-ready products, inform the development of industry standards, and result in capital deployments and associated General Rate Case (GRC) funding requests.

[4] *See* p. 2.

EPIC Program-driven Benefits

1. Increase Safety for the public and workforce by addressing electric system hazards:
   - The *DC Fast Charging Demonstration* uncovered a serious safety violation by an electric vehicle (EV) charging station operator, resulting in the operator correcting all such safety violations at all of its sites and preventing the safety violation from causing injuries to the public.
   - The *Distributed Cyber Threat Analysis Collaboration* project allows SCE to collaborate and share cybersecurity threats and defense mechanisms across stakeholder groups, which should reduce the probability of cyberattacks and the associated safety, reliability and economic impacts.
   - The *Comprehensive Hazards Assessment Tool* improves upon the challenge of reducing vulnerability and resilience to natural hazards, providing greater resiliency in the face of high impact, low probability hazard scenarios. It also provides the ability to leverage existing SCE resources used in new ways to plan, prepare and improve recovery from hazards. It also helps improve hazard preparedness in the long term, while also improving situational awareness during hazard events.
2. Improve Reliability of service to our customers:
   - The *Integrated Grid Project* substantially informed the technical requirements for SCE's Grid Management System (GMS), including the fault location, isolation and service restoration (FLISR) and Distributed Energy Resource Management System (DERMS). SCE forecasts that FLISR will help SCE customers avoid approximately 300 million customer minutes of interruption (CMI) by 2030, an estimated value to customers of $471 million, and that DERMS will provide an additional $134 million in reliability benefits by 2030.
   - One of the subprojects of the *Integrated Grid Project*, the *Electric Access System Enhancement* (EASE) project, informed how a distribution system operator can manage a transactive energy marketplace for large penetrations of aggregated DERs to provide day-ahead energy services for the distribution system. The benefit of these DER services could lead to substation and line upgrade deferrals on feeders with sufficiently high penetrations of DER—assuming that the necessary combination of controllable DERs is available. This increased DER hosting capacity could lead to cost-savings by deferring certain wires-only capital projects.[5] This could potentially provide an additional $300 million in savings by 2045, if SCE can defer projects using the necessary combination of controllable DERs. EPIC and U.S. Department of Energy funding will have played a critical role in allowing SCE to demonstrate these dynamic hosting capabilities before implementing them at a production scale territory wide. In the long run, the project's transactive energy market and control platform could provide an alternate revenue stream for DER owners, and likely accelerate the downward trend of cost to install residential and commercial DERs. The Smart Electric Power Alliance (SEPA) recently selected EASE as the 2022 SEPA Utility Transformation Project of the Year.[6]
   - *Next-Generation Distribution Automation* evaluated the Sentient remote fault indicator (RFI) with Gridstream communications, which resulted in 13.5 million fewer customer minutes of interruption over three years, equal to about $36 million in avoided customer outage costs. SCE expects RFIs to provide an additional $138 million of reliability benefits by 2030.

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[5] See "Benefits to Ratepayers" section in:
Castaneda, Juan, and Ioan, Andrew. *Assessment of a Distributed Energy Resource Management System for Enabling Dynamic Hosting Capacity*. United States: N. p., 2022. Web. doi:10.2172/1864777.

[6] https://sepapower.org/knowledge/sepa-announces-2022-utility-transformation-award-winners/.

- The *DER Dynamics Integration* project has informed how large numbers of DERs of various vintages and capabilities will interact with the distribution system and how SCE relaying protection systems will have to be adjusted. The project has demonstrated and verified the advanced functions of smart inverters for high DER penetration levels at a distribution feeder with a mix of smart, legacy, and traditional generation. The project found that the current protection setting of the feeder relay will not be affected; however, for higher penetration (120% and higher), protection mis-operation and mis-coordination issues will occur and require further investigation. Such findings will support grid reliability by ensuring the appropriate protection and operational settings if abrupt operating condition changes occur. The enhanced smart inverter settings would help to keep inverter-based DERs operational, making these resources more attractive to customer and likely stimulating higher customer adoption.

3. Reduce Costs for our customers through EPIC-demonstrated technology or process improvements:
    - The *Enhanced Infrastructure Technology Evaluation* determined that hardened vault blower fans could each save nearly $8,000 over their 10-year life from avoided equipment replacement costs. Deployment of this blower fan could save about $800,000 over the lifetime of the units SCE installs each year.
    - The *SA-3 Phase III Field Demonstration*, which is demonstrating a fully digital substation using process bus technology, is expected to result in potential cost savings of 10-20% when replacing substation relays using this technology, yielding cost savings of approximately $9.4 million per year.
4. Complementary Benefits such as GHG reduction:
    - The *Distribution Planning Tool* project advanced tools to simulate locational DER value and DER hosting capacity, supporting increasing amounts of DERs to safely connect to the system. A 10% increase in the total number of rooftop solar installations could displace an additional 26,000 metric tons of CO_2 annually, providing over $2,000,000 of CO_2 reduction benefits each year.
    - The *Distributed Plug-in Electric Vehicle Charging Resources* project is evaluating the use of fast charging integrated with energy storage to shift load and alleviate associated grid impacts. Shifting EV charging load could save over 27,000 metric tons of CO_2 per year, providing annual CO_2 reduction benefits of $2.1 million.
    - The *Vehicle-to-Grid Integration Using Onboard Inverter* project is demonstrating how EVs can interconnect with utility systems and become resources serving both customer and utility needs. Charging light-duty EVs is expected to reach 6.9% of peak load by 2030, but proper control can mitigate issues caused by fleet charging (e.g., 100 buses at 150kWh capacity can reduce demand by 15 MW).
    - The *Control and Protection for Microgrids and Virtual Power Plants* project is establishing a framework for standardized front-of-the-meter microgrid implementation and control and has been key in informing SCE's approach to the ongoing CPUC Microgrid OIR (R.19-09-009).

Additional Sources of Value:

1. Findings that support CPUC proceedings:
    - The *Integrated Grid Project* informed SCE's requirements for the GMS, which will be critical to realizing the Distribution Resources Plan's (DRP) vision by safely sending communications between the utility and third-party DER providers in real-time to meet system needs.
    - Technologies from *Next-Generation Distribution Automation* informed the development the distribution automation elements of the DRP Track 3 Sub-Track 2 Grid Modernization classification tables and definitions.

- The *Versatile Plug-in Auxiliary Power System* project results informed SCE activities in response to the Public Safety Power Shutoff (PSPS) proceeding for the "art of the possible" for mobile battery-based power systems that can serve as alternatives to diesel generators to provide temporary power.

2. Influence product development within the utility industry marketplace:
   - The *Integrated Grid Project* refined GMS vendors' product offerings and their product development roadmaps for DERMS and Advanced Distribution Management Systems (ADMS).
   - *Next-Generation Distribution Automation* prompted further development of Siemens' remote intelligent switch using SCE's decentralized protection logic.
   - Through *Next-Generation Distribution Automation*, SCE helped to advance Southwest Research Institute's development of their high impedance fault detection concept.
3. Inform Industry Standards for grid-connected technologies:
   - The *Integrated Grid Project* has better defined the Institute of Electrical and Electronics Engineers (IEEE) 2030.5 (Smart Energy Profile Application Profile) standard and how cyber-secure communication can be achieved between utilities and third parties to optimize DER operation on the grid.
   - The *DC Fast Charging Demonstration* methodology for monitoring power quality informed Society of Automotive Engineering (SAE) J2894/1: Power Quality Requirements for Plug-in Electric Vehicle Chargers. SCE co-chaired both SAE J 2894/1 and J2894/2 Power Quality Test Procedures for Plug-in Electric Vehicle Chargers.
4. Request GRC funding to support deployment of EPIC technologies and realization of expected benefits:
   - The *Integrated Grid Project* directly informed the GMS capital request included in SCE's 2018 and 2021 GRCs.
   - The *Distribution Planning Tool* informed SCE's request of $17.5 million for the System Modeling Tool in its 2021 GRC to support its evolving distribution planning processes and comply with DRP requirements.
   - *Beyond the Meter: Customer Device Communications* informed systems that were part of SCE's 2018 and 2021 GRC capital requests for Field Area Network (FAN) and other grid modernization capabilities.
   - *Next-Generation Distribution Automation* remote fault indicators were deployed using 2018 and 2021 GRC funding.
5. Present research and findings to external stakeholders at major industry conferences and in industry publications:
   - Different portions of the *Integrated Grid Project* have been presented at over ten different conferences and working group meetings.
   - The *Smart City* project was presented at DISTRIBUTECH 2022.
     - Remote Intelligent Switches from the *Next Generation Distribution Automation* project were presented at the 2021 PACWorld conference and DISTRIBUTECH 2018.
     - *Dynamic Power Conditioner* was presented at an Energy Storage Association symposium and DISTRIBUTECH 2020.

A full consensus table of the sets of measurements and benefits areas is included at the end of this report, as part of the Appendix A, Working Benefits.

IV. Overview

This section summarizes the benefits that have resulted from (or are expected to result from) SCE's EPIC 1, EPIC 2, and EPIC 3 projects. . The data from the project benefits was extracted from the project final reports that are filed with the EPIC Annual Report. Furthermore, SCE updated the project benefits shown in SCE's Phase 2 Opening Brief[7] to reflect the collaboration among EPIC Administrators in developing a single benefits analysis framework. If EPIC projects are successful, SCE will request capital deployment of these technologies through the General Rate Case (GRC) at the appropriate time.[8]

V. EPIC 1

Integrated Grid Project (IGP)

The IGP demonstrated the next generation grid infrastructure necessary to manage, operate and optimize the distribution grid with high penetrations of DERs. The project focused on the controls and protocols needed for optimal DER management, which advanced these grid infrastructure technologies and industry standards, and created a path to market through GRC requests. Moreover, the project directly supported the Commission's DRP proceeding.

Benefits

- SCE forecasts that GMS FLISR will help SCE customers avoid approximately 300 million customer minutes of CMI by 2030, with an estimated value to customers of $471 million.[9]
- SCE forecasts that the DERMS will provide $134 million in reliability benefits by 2030 based on its ability to help resolve "masked load" concerns associated with DERs.[10]
- The ability to connect additional DERs to the distribution grid without significant upgrades may reduce the cost of the interconnection to an individual customer, which is normally well over $10,000.
- Work done under this project laid the foundation for the commercial GMS being installed by SCE, which helped to reduce implementation risk and cost by identifying and resolving software and cybersecurity issues for GMS.
- As described in SCE's Pathway 2045 white paper,[11] up to 50% of single family homes in California are projected to have customer-sited solar by 2045, providing approximately 30 gigawatts (GW) of generation capacity, along with 10 GW of customer-sited storage, playing a key role in reducing electric sector GHG emissions from 63 million metric tons (MMT) in 2017 to 10 MMT in 2045. GMS will be critical in enabling SCE to fully leverage these resources when optimizing grid operations.

Quantitative Benefits Summary

	Measurement Areas		
	Reliability Improvement	**Value of Service**	**Interconnection Cost Savings**
IGP	300 million CMI by 2030	$605 million by 2030	>$10,000/customer

[7] R.19-10-005, Phase 2 Opening Brief, October, 02, 2020.
[8] GRC capital deployment requests reflect the *actual* benefits to operational activities and subsequent reduced costs.
[9] See Appendix B.
[10] See Appendix B.
[11] https://www.edison.com/home/our-perspective/pathway-2045.html.

Portable End-to-End Test System

This project demonstrated a robust and portable end-to-end toolset (PETS) that addresses: 1) relay protection equipment, 2) relay communications, and 3) pass/fail grades based on the results of automated testing using numerous simulated disturbances. This comprehensive protection system testing is crucial because existing tools provide a limited number of scenarios (disturbances) for testing and tend to focus on testing protection elements and not full protection system testing. PETS employs portable Real-Time Digital Simulators in substations at each end of the transmission line tested. This test method is more complicated than existing procedures, but provides more thorough testing, which is most valuable for complicated relay protection schemes used on critical transmission interconnection corridors.

Benefits

- While project results concluded that the demonstrated method was too complex and costly for most transmission lines, there are a few complex protection schemes where the system could be valuable, such as important system interconnection transmission lines. Outages on these important lines, which allow movement of energy between utility service territories within the Western Interconnection, take a high degree of coordination, and if a failure means the line is not able to be put back into service, more high-cost electricity may have to be bought in order to alleviate congestion on the system.
- The demonstrated system showed a more thorough method of testing relay protection schemes on transmission lines. This testing could prevent mis-operation of relay protection schemes (22 have been reported on the transmission system over the last five years), which would reduce the potential for outages on major transmission lines. To illustrate the value of such work, the 2011 Southwest Blackout, which was relatively short in duration, resulted in direct economic losses of $97-118 million.[12]

Quantitative Benefits Summary

	Measurement Areas	
	Potential Mis-Operation of Transmission Relays Avoided	Potential Economic Losses from Blackout Avoided
PETS	4.4/year	$97-$118 million/event

Dynamic Line Rating Demonstration

This project demonstrated a system that provides transmission operators with near real-time transmission line ratings based on actual weather conditions as opposed to fixed pre-calculated ratings given by line manufacturers. Transmission line owners apply fixed thermal rating limits for power transmission lines. These limits are based on conservative assumptions of wind speed, ambient temperature and solar radiation. They are established to ensure compliance with safety codes, maintain the integrity of line materials, and ensure network reliability. Monitored transmission lines give operators the information necessary to safely increase the utilization of the lines, thereby improving network efficiency without increasing safety or reliability risks.

Benefits

- Dynamic line ratings could increase the transmission capacity of existing transmission infrastructure, which could potentially help to defer the buildout of additional transmission infrastructure.

[12] https://hazards.colorado.edu/uploads/quick_report/miles_draft_2012.pdf.

- SCE's project experience will help improve the dynamic rating system tested by showing how to more easily integrate the technology with energy management systems.
- Increased transmission capacity, when allowed by conditions, could increase transmission of renewable energy from solar and wind farms and reduce GHG emissions. SCE's Pathway 2045[13] whitepaper describes the need for 80 GW of new utility-scale clean generation and 30 GW of utility-scale energy storage over the next 25 years, and how further grid investment will be required to support these resources. Dynamic line ratings can help to increase transmission capacity utilization, thereby reducing the total investment required to support this load growth.
- SCE's Pathway 2045 estimates a cost of $33 to $53 billion in non-distribution system costs to move necessary generation to the grid by 2045. Using dynamic line ratings could reduce the need for transmission upgrades.

Quantitative Benefits Summary

	Measurement Area
	Cost Reduction
Dynamic Line Rating	Some portion of $33-53 billion by 2045

Volt/VAR Control of SCE Transmission System

The transmission Volt/VAR optimization project (VVO) is a tool demonstrated for SCE's Grid Control Center use that attempts to minimize the system voltage violations observed within the SCE transmission system. The VVO provides operators with a list of potential control actions to improve the system voltage profile. Through consideration of system-wide effects and use of an optimal power flow model, the VVO tool reallocates reactive power resources to minimize the system-wide megawatt (MW) losses.

Benefits

- As part of the project, the team used the Common Information Model (CIM) standard[14] to transfer data from the EMS, SCE's existing transmission operations system, to the VVO test system. This increased SCE's experience with the CIM, which is now being used in the EMS and Distribution Management System (DMS). This experience with CIM will be beneficial in the implementation of SCE's new GMS. The CIM model will be the basis for the data structure on the GMS's operational service bus.
- SCE and Nexant (the VVO software is a customized implementation of Nexant's Grid360 commercially available optimization engine) determined that there could be potential financial benefits (energy and capacity) yielding approximately $7.5M for the two test cases combined.
- Use of a volt/VAR control system allows a utility to make more efficient use of their transmission infrastructure by reducing energy loss. The SCE/Nexant demonstration estimated that 1.6 million megawatt hours (MWh) could be saved through the use of the system.
- While implementation of the tool was ultimately deemed to be too labor-intensive for operator participation, the demonstration has provided numerous lessons learned. In particular, the project advanced understanding of the feasibility of implementing a global Optimal Power Flow tool for voltage and

[13] https://www.edison.com/home/our-perspective/pathway-2045.html.
[14] IEC 61970.

VAR control, which resulted in a component of the GMS system requested in SCE's Grid Modernization 2021 GRC request.

- The project tested a system designed to minimize voltage violations and satisfy operational constraints, which would reduce the likelihood of a transmission outage. To illustrate the value of such work, the 2011 Southwest Blackout, which was relatively short in duration, resulted in direct economic losses of $97-118 million.[15]

Quantitative Benefits Summary

	Measurement Areas		
	Energy Loss Reduction	**Financial Benefits**	**Potential Blackout Avoidance**
Volt/VAR Control	1.6 million MWh	$7.5 million	$97 million - $118 million/event

Distribution Planning Tool

The *Distribution Planning Tool* helps facilitate new advanced distribution circuit modeling tools, which are necessary to both support two-way power flows and mitigate voltage and power quality issues resulting from DERs. The project demonstrated new distribution models to simulate commercial loads, locational DER value, energy storage and EVs for GridLAB-D. The project also created a dynamic DER hosting capacity analysis based on the CYME's CYMDIST modeling tool. This hosting capacity methodology was used to create hosting capacity limits for SCE's Distributed Energy Resource Interconnection Map (DERiM) to share with the public.

Benefits

- The project added functionality to industry standard modeling software:
    - Models were demonstrated/upgraded for the GridLAB-D product - https://www.gridlabd.org/ - a commercial load/demand response, valuation framework to calculate locational value of DERs, energy storage, and electric vehicles.
    - A method was demonstrated to use the CYMDIST distribution simulation product (http://www.cyme.com/software/cymdist/) to calculate the maximum amount of DERs that can be connected without adverse impacts to the distribution system.
- The *Distribution Planning Tool* demonstration was the first iteration of what would become SCE's System Modeling Tool, which was approved in the 2018 GRC.
- The tools that resulted from this project help estimate the quantity of renewable resources that can be installed on distribution circuits without triggering distribution upgrades. To the extent this leads to increased DER adoption, it reduces GHG emissions and facilitates California's goals for decarbonizing the grid. On average, a 5-kW rooftop system providing 2 MWh per year could displace 1 metric ton of CO_2 per year. Providing a 10% increase in the total amount of solar installed could displace an additional 26,230

[15] https://hazards.colorado.edu/uploads/quick_report/miles_draft_2012.pdf

metric tons of CO_2 per year,[16] which equates to over $2,000,000 in CO_2e reduction benefits annually by 2030.[17]

- These tools identify where and what size DERs can be installed on the distribution grid without triggering a distribution upgrade. Customers interested in installing solar panels in locations where no transformer and service cable upgrades are required could save on interconnection costs, which are normally well over $10,000 per project, provided available DER hosting capacity is available.
- The methodologies demonstrated in this project can identify high-DER penetration scenarios that would cause overloading or voltage problems in the distribution system. If these conditions were allowed to persist, distribution equipment might operate outside of their ratings and cause energized wires to fall down or transformers to fail in service, leading to both potential safety and reliability issues. While SCE has yet to see this level of DER penetration on its grid, this analysis would be able to identify forecasted violations and allow distribution planners to develop solutions to eliminate this risk.

Quantitative Benefits Summary

	Measurement Areas	
	GHG Reduction	**Interconnection Cost Reduction**
Distribution Planning Tool	26,230 metric tons CO_2/yr	Over $10,000 per project

Wide-Area Reliability Management & Control

This project monitored the stability of the transmission system at Devers Substation and then used the Power Oscillation Damping function of the Devers Static VAR Compensator to demonstrate how this function can increase system stability and decrease the potential for system instability from sudden power disruptions, such as loss of major generation or load. Increased stability can help prevent cascading outages and maintain system integrity, especially as the grid transitions towards intermittent power sources.

Benefits

- The monitoring system provided SCE's Protection Engineering organization with insight into large variations of short circuit capability and its impact on protection scheme operation.
    - This demonstration prompted SCE's Protection Engineering and Protection Asset Engineering organizations to launch additional projects to evaluate inverter-based generation short circuit performance and protection scheme performance under these conditions.
    - SCE's Transmission Planning organization launched an additional project to estimate the needed system inertia and how it could be obtained from inverter-based generation resources to improve grid stability. Inertia substitution is a research topic area in SCE's EPIC 4 Investment Plan.

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[16] See Appendix B.

[17] 26,230 MT CO2 x $78.02/CO2e MT (CEC 2030 Mid Case in 2019 IEPR) = $2,046,467.

- This demonstration informed the requirements of future components of SCE's GMS—to help maintain system stability as increasing numbers of inverter-based renewable energy resources interconnect with the grid.

Quantitative Benefits Summary

	Measurement Area
	Potential Blackout Avoidance
Wide-Area Reliability Management & Control	$97 million - $118 million/event

SA-3 Phase III Demonstration

The project expands on the results of SCE's American Recovery and Reinvestment Act funded SA-3 Distribution demonstration (part of the Irvine Smart Grid Demonstration) by demonstrating a transmission substation architecture and new technologies that provide cost reduction, capability improvements, compliance, and adaptability to emerging requirements. It features transitioning to a fully-digital substation and centralized data collection and compliance. This design has been built in the lab environment and tested through new methods utilizing a real-time digital simulator (RTDS). Since this is a transmission substation, centrally managed cybersecurity measures needed to be put in place to meet NERC CIP standards.

Benefits

- The RTDS was used for real-time dynamic testing of the substation control, automation, and relaying design. The SCE methods were shared with the RTDS manufacturer for dissemination to other utilities using their product. Through the project, the team found various incompatibilities between device manufacturers utilizing standards-based communications, which has resulted in product updates from various product vendors.
- The fully integrated design is expected to become SCE's new transmission substation control and protection design, as well as provide updates to the distribution substation design with the demonstrated technologies.
- Project results helped set the stage for an EPIC 3 project to investigate how to use the IEEE 61850 process bus standard, which is expected to further reduce new substation costs by 10-20% and could result in cost savings of approximately $9.4 million annually.[18]

Quantitative Benefits Summary

	Measurement Area
	Cost Reduction
SA-3 Phase III	$9.4 million/yr

[18] $2.5M for a substation relay replacement project (range of $2-$3M) x 15% cost reduction (10% - 20%) x 25 substations per year (range of 20-30) = $9.375 million

State Estimation Using Phasor Measurement Technologies

This project provided wide-area situational awareness of the Western Electricity Coordinating Council (WECC) region to SCE system operators. The project allowed SCE to detect events outside of SCE's footprint and enhanced our ability to take timely corrective actions to prevent extreme events—such as the Pacific Southwest Blackout of 2011 and the Western Interconnection Blackout of 1996. This project expanded synchrophasor observability to 36 additional substations using data from the phasor measurement units (PMUs) already installed at 13 substations. This expansion can increase SCE's observability via the Electric Power Group's enhanced Linear State Estimator without the need for additional PMU installations – creating the potential for substantial cost savings.

Benefits

- Synchrophasor data was used in the report of the Blue Cut Fire to determine that inverter-based resources tripped erroneously due to frequency-related protection functions, leading to 1,200 MW of solar photovoltaic (PV) generation loss. Following the recommendations based on that analysis, the next time a disturbance in the Southern California area was analyzed, there was no erroneous frequency tripping thanks to actions taken as a direct result of the recommendations of the Blue Cut report.
- As the system becomes increasingly reliant on inverter-based resources like solar and wind, it will become increasingly vulnerable to a cascading blackout as a result of resource loss events like the Blue Cut Fire. The high-speed measurements provided by synchrophasors in event analyses are essential to discovering necessary mitigations to prevent system-wide blackouts. Providing real-time phase angle information to SCE operators can assist them in line reclosing, monitoring grid stress, and detecting islanding conditions (i.e., when distributed generation continues providing power to a location even though the electric utility grid is down).
- Using the Real-Time Dynamics Monitoring System software to expand synchrophasor observability to 49 additional 220/500 kV substations will reduce the cost of installing, maintaining, and operating synchrophasor units at these additional substations.
- Events detected outside of SCE's power system footprint can enhance operators' abilities to take timely corrective actions to prevent extreme events (e.g., the Pacific Southwest Blackout of 2011 and the Western Interconnection Blackout of 1996).

Quantitative Benefits Summary

	Measurement Areas	
	Solar Curtailment Avoided	**Cost Reduction**
State Estimation Using Phasor Measurement Technologies	1,200 MW/event	Cost of PMUs at 36 substations

Beyond the Meter: Customer Device Communications

The project demonstrated the integration of customer and third-party meters that monitor PV and energy storage systems, collect measurement data from these devices, and communicate with SCE's DMS to improve situational awareness of the distribution grid. This work also tested ways to communicate through two candidate radio systems then being considered for SCE's new FAN. Protocols used included RS-232, DNP, and TCP/IP. Important cybersecurity questions were also uncovered during this demonstration.

Benefits

- This EPIC demonstration informed new requirements for the FAN radio system in terms of the interface between metering and control devices, IEEE 2030.5 communications protocol for the DERMS portion of GMS, and cybersecurity protection for the communication protocols. These systems informed SCE's 2018 and 2021 GRC capital requests for FAN and other Grid Modernization capabilities.
- This project complemented the *Integrated Grid Project* by focusing on communication and associated cyber security related issues. Accordingly, lessons learned supported DRP Track 3 Sub-track 2 activities regarding Grid Modernization. The results of this EPIC project informed the requirements for the FAN and other communication protocols.
- Software systems used in this project will allow for the safe and reliable integration of additional customer PV and energy storage systems. On average, a 5-kW rooftop system providing 2 MWh per year could displace 1 metric ton of CO_2 per year. A 10% increase in the total number of projects installed could displace an additional 26,230 metric tons of CO_2 per year, which would equate to over $2,000,000 in CO_2e reduction benefits annually by 2030.[19]
- The integration of third party meters with SCE's Supervisory Control and Data Acquisition (SCADA) communications systems as proven by this demonstration will help provide SCE with near real-time situational awareness of larger DERs deployed on its distribution system that are not presently required to support telemetry. Such insights mean grid operators need to make fewer assumptions about what is happening on distribution circuits and can better prevent line overloads due to excess generation by dispatching batteries to smooth power flow and maintain proper voltage to customers.

Quantitative Benefits Summary

	Measurement Areas
	GHG Reduction
Customer Device Communications	26,230 metric tons/yr CO_2

Distributed Optimized Storage (DOS)

The *DOS Protection and Control* project demonstrated protection and control aspects of integrating energy storage devices on distribution circuits to identify grid reliability benefits and increase DER integration capacity. This project also investigated how energy storage devices can be used for grid reliability, while also providing ancillary services to the California Independent System Operator (CAISO) markets, thereby enabling multiple benefits and revenue streams. Use cases were developed to determine requirements for the control systems necessary to accomplish these stacked energy storage benefits to help support the Commission's DRP and energy storage proceedings.

Benefits

- This project supported the DRP's Distribution Infrastructure Deferral Framework (DIDF), which requires utilities to identify wires solutions that have the potential to be deferred by DERs. Project results helped

[19] See Appendix B.

inform calculations for DER operational requirements used to prioritize candidate deferral projects and ultimately used as technical requirements within SCE's annual DIDF Request for Offers (RFO). Lessons learned through this project on how to optimize the implementation of storage supporting distribution operations informed SCE's proposals and activities under energy storage proceedings.[20] Specifically, these learnings informed SCE's workshop participation within the Energy Storage Rulemaking on Multiple Use Applications,[21] which helped support the Commission's decision[22] defining the ability for energy storage to provide multiple benefits and services on the distribution and transmission system.
- The project demonstrated the ability to connect additional DERs to the distribution grid without significant line or transformer upgrades, which would reduce infrastructure costs.
- This project helped to inform communications standards, such as IEEE 2030.5 and Distributed Network Protocol (DNP) 3.0 adapted for battery systems.
- Avoided procurement and generation costs at Johanna Jr and Camden Substations over the one year period at the end of the work were estimated at $220,000.[23]

Quantitative Benefits Summary

	Measurement Areas
	Cost Reduction
DOS	$220,000/yr

Outage Management and Customer Voltage Data Analytics Demonstration

This project determined how to best collect, store, and integrate voltage and energy consumption data with T&D applications to provide analytics and visualization capabilities. This project focused on more effective and efficient ways of calculating System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI), and Momentary Average Interruption Frequency Index (MAIFI) for internal and external reporting. A total of 14 use cases were explored for other applications of the data, including verification of transformer loading and proper customer voltage.

Benefits

- Severely overloaded distribution transformers can be identified and replaced before customers experience outages due to a failed transformer. Distribution transformer failures cause 7.1 minutes of Repair SAIDI each year, which equates to approximately $95 million in annual customer outage costs.[24] SCE has used the techniques and calculations demonstrated in this project to create its Reliability Operations Center (ROC). SCE now has staff dedicated to refining these methods to actively address grid reliability challenges. This better assists operations and field crews to identify problems to limit outage durations.
- The project demonstrated methods to utilize smart meter data for T&D applications. The use cases explored by this project have provided requirements that can be used in Grid Modernization efforts at SCE and other utilities, saving the time and expense that would have been required to develop on their own. The SCE ROC

[20] R.10-12-007 and R.15-03-011.
[21] R.15-03-011.
[22] D.18-01-003
[23] Distributed Optimized Storage Protection and Control Demonstration Final Report
[24] 7.1 minutes of repair SAIDI x 5 million customers x $2.69/CMI = $95,495,000

is an example, using techniques pioneered by this project to gather data from customer meters to help visualize the state of the distribution grid.

- During 2015, SCE presented an overview of the project at two industry meetings:
  - 4th Annual Utility Analytics Conference, Phoenix, March 5th 2015, session 201 – presentation entitled "Advanced Analytics for Voltage Management"
  - EPIC Innovation Symposium, December 3, 2015, presentation on "Outage Management and Customer Voltage Analytics"

Quantitative Benefits Summary

	Measurement Areas		
	Potential Outages Avoided	Potential Value of Service Improvement	Industry Presentations
Outage Management and Customer Voltage Data Analytics	7.1 minutes SAIDI/yr	$95 million/yr	2

Enhanced Infrastructure Technology Evaluation

This project evaluated the effectiveness of enhancements to grid infrastructure—vault blowers, in particular. Vault blowers are used to keep distribution vaults, which contain transformers, at an acceptable ambient temperature. The demonstration involved examining issues with current ventilation systems, developing a new equipment specification to address these limitations, and field demonstrating a prototype built to these new specifications. The project resulted in a path to market, because SCE's Distribution Apparatus Engineering group has decided to adopt this new vault blower for grid use.

Benefits

- The new vault blower fans are expected to have a 10-year lifetime, eight years more than the 2-year expected life of existing fans, which reduces overall costs. SCE estimates this new blower will save $7,822/unit over its 10-year life. As SCE currently installs over 100 blowers per year, this new blower fan could save approximately $800,000 over the lifetime of the blower fans installed in a single year.
- The project results help to reduce vault overheating, which can cause transformer failures and result in outages and possible injury to the public. This is a low probability occurrence, but the impact would be significant to customers.

Quantitative Benefits Summary

	Measurement Areas
	Cost Reduction
Enhanced Infrastructure Technology Evaluation	$800,000 over lifetime of fans installed in one year

Regulatory Mandates: Submetering Enablement Demonstration

In 2013, the Commission directed the Utilities to implement a two-phase submetering pilot using EPIC funds. Meter Data Management Agents were contracted to sign up customers, install submeters, collect meter usage data, and send usage data to SCE. SCE calculated bills using separate rates for normal usage and EV usage.

Benefits

- If suitable submeters, uniform data communications protocols, and a reliable billing process could be established, there could be significant savings for EV customers. Project estimates show a customer savings of as much as $50 per month depending on the rates put in place. In addition, a customer may be able to avoid a panel upgrade that sometimes costs thousands of dollars.
- Based on the learnings from this project, SCE incorporated next-step submetering exploration into the EPIC 3 Service Center of the Future project. As part of that effort, SCE is engaging vendors for both switchgear and meters on requirements and will deploy submeters and conduct measurements to inform industry and guide concurrent industry and Commission submetering efforts.
- 78% of respondents said they were extremely or somewhat satisfied with their overall submetering service.
- 82% of respondents said they would recommend submetering services to a friend or colleague based on their Phase 1 Pilot experience.
- 77% said they would be interested in participating in the Phase 2 pilot.
- Customers participating in the Phase 1 Pilot reported charging their EV during off-peak hours 90% of the time vs 48% before the Pilot.

Quantitative Benefits Summary

	Measurement Areas	
	Customer Cost Savings	Customer Service
Submetering Enablement	$50/month	82% of respondents said they would recommend submetering services to a friend based on their Pilot experience

Cyber-Intrusion Auto-Response and Policy Management Systems (CAPMS)

The *CAPMS* project investigated the use of Bayesian decision tree logic to implement configurable security policies into an existing cybersecurity system to improve communications between devices and back office control centers. These improved communications improve grid monitoring, load forecasting, coordinated operations and automation of existing and new equipment, which furthers grid resiliency. The system correlates events from secure sensor input points and other communications infrastructure, determines the likelihood of various types of attacks and responds accordingly. The project was co-funded with contributions from the U.S. Department of Energy (DOE) ($3M), Duke Energy ($1.2M), and SCE/EPIC ($1.6M).

Benefits

- A system such as CAPMS helps to prevent or reduce the duration of outages caused by cyber and physical attacks. SCE's RAMP filing estimated the impact of three different outcomes from these types of attacks, varying from 7 million customer minutes of interruption to over 342 million customer minutes of interruption.[25]

- Methods demonstrated in this project have been shared at industry conferences and in reports[26] The final report was submitted to the DOE filed November 11, 2015.
- The project results help reduce development expense of building and integrating a commercial system into SCE's cybersecurity suite. Further, SCE's RAMP filing estimated outcomes of potential cyberattacks varying from over $200,000 (with no impact to service or data) to over $80 million.[27]

Quantitative Benefits Summary

	Measurement Areas	
	Potential Reliability Benefit	**Potential Financial Benefit**
CAPMS	7 million – 342 million CMI avoided per event avoided	$200,000 - $80 million per event avoided

Next-Generation Distribution Automation

This project focused on improving equipment and communications for remote fault indicators (RFIs), remote intelligent switches, intelligent fuses, and high impedance fault detection, to support distribution automation (DA) to improve reliability, reduce customer minutes of interruption, reduce momentary outages, improve safety, and support DER integration. DA products were tested and evaluated to support improvements to their performance and communications capabilities and then field demonstrated. The components successfully demonstrated could become SCE's standard and be implemented on the distribution system in the coming years. The RFIs have already been deployed on SCE's system.

Benefits

- The Sentient RFI with Gridstream communications can improve reliability by communicating fault events and providing distribution circuit loading data to grid operators. The RFI deployment resulted in 4.5 million CMI avoided annually between July 2018 and June 2020 (approximately $36 million of customer reliability improvements already experienced).[28] An additional $138 million of reliability improvements is expected by 2030.
- The Siemens remote intelligent switch system was developed using SCE's decentralized protection logic. The rapid location and isolation of faults through use of remote intelligent switches would reduce outage extent and duration. It is estimated that the switches could reduce short power interruptions by 36% and the duration of customer interruptions by 40%.
- The G&W I-Fuse was enhanced based on input from SCE but would need to have its weight reduced to be a viable product. The I-Fuse allows rapid restoration of power to customers on distribution circuit lateral branches, reducing SAIDI.
- The Southwest Research Institute's high impedance fault detection concept was improved with SCE's assistance and is now ready to move to field demonstration.

[25] See Chapter 6 of SCE's 2018 Risk Assessment and Mitigation Phase Report, at pp. 6.17 – 6.19.
[26] https://www.osti.gov/biblio/1329008/
[27] See Chapter 6 of SCE's 2018 Risk Assessment and Mitigation Phase Report, at pp. 6.14 – 6.19.
[28] 4.5 million CMI annually (2018-2020) x 3 years x $2.69/CMI = $36.315M

Quantitative Benefits Summary

	Measurement Areas	
	Reliability Benefit	Value of Service Benefit
Next-Generation DA	4.5 million CMI avoided/yr	$174 million

VI. EPIC 2

Integration of Big Data for Advanced Automation Customer Load Management

This project demonstrated the Common Smart Inverter Profile (CSIP) to support California's Rule 21 interconnection rules, which require the implementation of IEEE 2030.5 communications protocol to interface with third-party PV and energy storage systems. Specifically, this project examined use cases for grouping, monitoring, controlling, and registering using IEEE 2030.5. Furthermore, SCE coordinated this project with the CEC's Program Opportunity Notice 14-303. SCE and the CEC created project synergies by combining utility servers, customers and 2030.5 clients. The collaborative teams discovered issues related to aggregated smart inverter commissioning and support processes, including setting up communications, monitoring and troubleshooting issues, and the need for clearly defined roles and responsibilities for the multiple stakeholders involved.

Benefits

- The smart inverter and communications functionalities demonstrated by the project are being leveraged for EPIC 3 projects relating to microgrids and DERMS. The smart inverter and communications functionalities are intended to be used by DERMS to reliably control DERs. DERMS will provide approximately $134 million in reliability benefits by 2030 based on the system's ability to help resolve masked load concerns associated with DERs.[29]
- The project worked with Kitu Systems and Pika Systems to demonstrate the IEEE 2030.5 capabilities of their systems and improve their products, which included an IEEE 2030.5 server software and interface to smart inverters (SunSpec Modbus over TCP/IP communications protocol).

Quantitative Benefits Summary

	Measurement Area
	Value of Service Benefit
Integration of Big Data	$134 million by 2030

Advanced Grid Capabilities Using Smart Meter Data

The project examined the use of residential and small commercial smart meter data to provide insights into the relationships between customers and their respective service transformers through line phasing. SCE tested several algorithms to see how accurately smart meters can identify meter-to-transformer and meter-to-phase relationships. Improvement to these relationships can improve information on outages, voltage levels and transformer loading, thereby improving safety and reliability.

[29] See Appendix B.

Benefits

- SCE's Reliability Operations Center (ROC) uses smart meter data and algorithms to identify failed transformers in real-time, thereby helping field crews identify failed equipment and reducing customer outage duration. The reliability of distribution transformers can be improved through better knowledge of transformer loading. Overloaded transformers can be replaced before failure, thereby reducing customer outage duration. The ROC estimates that in 2018 alone this program avoided nearly 500,000 minutes of customer interruption.
- Replacing transformers proactively, instead of after failure in-service, can potentially reduce the overtime paid to perform the transformer replacement on an emergency basis.
- Use of these algorithms eliminates labor-intensive activities such as field verification of phase and transformer-to-meter associations for planning and load switching operations, improves transformer load management, and enables more timely and accurate customer notifications about power outages and restorations.

Quantitative Benefits Summary

	Measurement Area	
	Reliability Benefit	Value of Service Benefit
Advanced Grid Capabilities	500,000 CMI avoided	$1,345,000 value of service saved[30]

Proactive Storm Impact Analysis Demonstration

This project evaluated robust storm predictive analytics based on improved modelling tools to better forecast the impact of approaching storms and improve our understanding of how to most efficiently and effectively pre-stage staff and materials prior to the storm's arrival. This project included integration of weather forecasts, operations information, and resource usage data to improve SCE's operations and further support California and the Commission's understanding of climate change's effects on customers.

Benefits

- The project results identified a need for commercial products and helped to influence vendors to create commercial technologies that combine the use of localized weather data and web reporting with visualization. Five years after project kickoff, products are now available from the project vendor IBM (Weather Company Outage Detection)[31] and from GE (Storm Readiness).[32]
- This project helped to reduce weather-related customer minutes of interruption, which dropped by 46% between 2017 and 2018, from over 169 million CMI to just under 92 million CMI.
- This tool enhances resource utilization efficiency and planning for the Transmission & Distribution and Corporate Incident Management teams during storm conditions. By providing weather impact awareness, the tool enables SCE's Grid Operations to appropriately pre-stage and schedule T&D operations resources to avoid excessive overtime. In the 2021 GRC, SCE forecasted $15 million per year in storm-related O&M expenses and between $44 million and $50 million per year in storm-related capital expenses. A theoretical

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[30] 500,000 customer minutes of interruption x $2.69/CMI = $1,345,000
[31] https://www.ibm.com/downloads/cas/BWNZBNQ3.
[32] https://www.ge.com/digital/sites/default/files/download_assets/grid-analytics-storm-readiness-datasheet.pdf.

10% reduction could save SCE customers over $5 million per year. SCE believes this project can help enable some of these cost savings.

Quantitative Benefits Summary

	Measurement Areas		
	Market Products Influenced	Reliability Benefits	Potential Storm Cost Savings
Proactive Storm Impact Analysis	2	77 million CMI avoided/yr	$5 million/yr

Next Generation Distribution Equipment & Automation – Phase 2

The project focused on advancing distribution automation by integrating advanced control systems, modern wireless communication systems, and the latest breakthroughs in distribution equipment and sensing technology to develop a complete system design that would serve as a standard for distribution automation and advanced distribution equipment. This will help improve reliability via fewer customer minutes of interruption (and fewer momentary outages), improve safety, and support DER integration. Topics being pursued include a hybrid pole, antenna for underground installations, underground remote fault indicator, monitoring improvements in the Long Beach network area, remote intelligent switch, intelligent fuse, and high impedance fault monitoring. These enhanced technologies will be demonstrated on real distribution equipment and, if successful, will become SCE standards and be implemented on the distribution system in the coming years.

Benefits

- The project's demonstration of remote intelligent switches that rapidly locate and isolate faults reduce outage extent and duration (and in some cases help customers avoid outages altogether). SCE estimates these switches could reduce short power interruptions by 36% and the duration of customer interruptions by 40%. These devices also provide better grid operator situational awareness that can indicate emerging problems that might lead to outages.
- The Intelligent Fuse allows rapid restoration of power to customers on distribution circuit lateral branches, reducing SAIDI.
- The high impedance fault detection system could give an accurate fault location, reducing the time for a repair crew to find and fix the problem—and more crucially, de-energize a circuit to reduce wildfire ignition risk.
- Presented on remote intelligent switches at the 2021 PACWorld Conference and Distributech 2018.

Quantitative Benefits Summary

	Measurement Area	
	Potential Reliability Improvement	External Knowledge Sharing
Next Generation Distribution Equipment & Automation	36% reduction in number and 40% reduction in duration of outages	2 presentations

System Intelligence and Situational Awareness Capabilities (Still in Progress)

This project is evaluating process bus technology, starting with a fiber-optic current transformer field demonstration and then a laboratory demonstration of a process bus substation. This demonstration is expected to reduce engineering and construction wiring complexity of substation protection and control systems while maintaining or reducing project cost. The project is investigating and testing the conversion of existing hard-wired schemes to their digital equivalents, and testing new protection, automation, and control configurations in order to improve equipment self-monitoring capabilities, reduce deployment time, and integrate intelligent algorithms. Additional benefits include advanced applications with the latest substation automation technologies, next generation control systems, and the latest breakthroughs in substation equipment.

Benefits

- New standards for connecting substation sensors to protective relays (IEC 61850 process bus) reduce the amount of wiring needed in a substation and makes it easier to modify the substation configuration when needed. The process bus is estimated to save 10-20% on substation design and construction costs. The availability of automated test tools is expected to provide additional cost benefits by reducing the time needed to perform substation testing.
- Advanced automation and controls prevent mis-operation of substation equipment and reduce the number and length of outages. Fully digital substation technologies, such as an IEC 61850 process bus, enable a greater degree of device health monitoring, which would be foundational for new predictive maintenance applications.
- SCE shared recommendations with the vendor (Triangle MicroWorks) to improve their Distributed Test Manager (DTM) product, which is used to perform automated tests to confirm proper substation system behavior.
- Presented at IEEE Green Energy and Smart Systems Conference in 2020.

Quantitative Benefits Summary

	Measurement Area	
	Market Product Refined	Knowledge Sharing
System Intelligence and Situational Awareness Capabilities	1	1 presentation

Regulatory Mandates: Submetering Enablement Demonstration – Phase 2

This project represents Phase 2 of the pilot directed by the Commission to pilot submetering. Phase 2 consisted of a field pilot with 151 residential customer submeters. Three Meter Data Management Agents were contracted to sign up customers, install submeters, collect meter usage data and send usage data to SCE. SCE calculated bills using separate rates for normal usage and EV usage. While there were challenges with the implementation of the field pilot, a third-party evaluator found that 91% of customer respondents said they were extremely or somewhat satisfied with their overall submetering service.

Benefits

- If suitable submeters, uniform data communications protocols, and reliable billing processes could be put in place, there could be a significant savings for customers with EVs. Project estimates indicate customers could saving up to $50 per month, depending on the rates put in place.
- The submetering pilot led to recommendations that will allow third parties to provide energy services with Level 2 chargers and the associated metering directly to customers and tie in economical tariffs and services beneficial to vehicle-grid integration. Making it easier for customers to install Level 2 chargers (and reducing the cost of charging at home), should increase the attractiveness of EVs to customers with range or charging anxiety.
- SCE's Pathway 2045 whitepaper[33] highlights the need for 26 million electric passenger vehicles to reach carbon neutrality. 90-95% of EVs are charged at home, and many EV customers use Level 1 120-volt systems to charge to avoid the added expense of Level 2 smart chargers and new utility metering. Level 2 chargers are more efficient than Level 1 chargers, reducing energy costs and GHG emissions. An estimated 7% to 15% efficiency gain on 90% of EVs could reduce GHG by approximately 4,000 metric tons of CO_2 per year,[34] which equates to approximately $312,000 in CO_2e reduction benefits annually by 2030.[35]

Quantitative Benefits Summary

	Measurement Area	
	Customer Savings	**GHG Reduction**
Submetering Enablement	$50/month	4,000 metric tons of CO_2/yr

Versatile Plug-in Auxiliary Power System (VAPS)

This project demonstrated the use of advanced lithium-ion battery systems in utility fleet vehicle applications as a means of facilitating progress to full electrification to support SCE's Pathway 2045 and California's decarbonization goals. The VAPS Project consisted of six subprojects – light-duty vehicle integrated platform; heavy-duty platform; medium-duty platform; and small, medium, and large power systems to electrify fleet subsystems or auxiliary loads – that attempted to electrify some of SCE's fleet vehicles and certain jobsites that seemed amenable to electrification. Overall, the VAPS Project demonstrated that advanced lithium-ion battery power systems were superior to traditional engine powered and lead-acid systems for auxiliary loads and helped inform several electrification strategies for SCE's fleet.

Benefits

- The VAPS project demonstrated the financial benefits of reduced or eliminated gasoline and diesel fuel consumption when vehicles and equipment are electrified. For example, the project demonstrated that the conversion of one type of truck in the SCE fleet with just an idle-off solution would save over $1,200 per year. VAPS also provided a new solution for a purely battery-operated cable puller for the fleet, which would eliminate all fuel for those devices. This VAPS solution for cable pullers was adopted by SCE's fleet.

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[33] https://www.edison.com/home/our-perspective/pathway-2045.html.
[34] See Appendix B.
[35] 4,000 MT CO2 x $78.02/CO2e MT (CEC 2030 Mid Case in 2019 IEPR) = $312,080.

- SCE demonstrated the many ways that modern lithium-ion battery systems could be integrated with traditional fleet work vehicles and equipment. In each case, GHG emissions are reduced such that progress can be made on electrifying all 6,000 vehicles in SCE's fleet. For example, SCE demonstrated that electrifying 21 Ford F-550 TA-40 Troubleman trucks reduced the engine idle time by 50% to 100%. Over a four-month reporting period, the total engine-on idling time was reduced from 445 hours to 280 hours. Based on SCE's emissions testing, this corresponds to a reduction of at least 832 kg of CO_2 over the test period.
- The data and experience provided by the VAPS project informed SCE fleet decision makers on how to set and achieve SCE's fleet electrification goals, in particular the electrification of 30% of medium-duty vehicles pick-up trucks and 8% of heavy-duty vehicles by 2030. The lower targets for larger and more complex vehicles were informed by the challenges demonstrated through the VAPS project.
- The results of this project helped refine vendor products like mobile cable pullers and mobile battery generators that are useful to SCE and other electric utilities. For example, one of SCE's large equipment vendors provided a VAPS-type small system designed for light vehicle auxiliary load electrification. SCE tests showed that the system failed to meet power quality standards. SCE then identified a charger system supplier (known from separate lithium-ion battery work), tested their charger as a replacement, and demonstrated that it was effective and met SCE and industry standards. In the case of medium VAPS, the project activity coincided with the emergence of a new vendor and resulted in a new equipment class for regular acquisition by the fleet – the electric cable puller. Currently, the SCE fleet is testing a new lithium-ion powered auxiliary hydraulic system that shows readiness for further fleet deployment based on lessons learned and influence from VAPS.

Quantitative Benefits Summary

	Measurement Areas	
	GHG Reduction	**Cost Reduction**
VAPS	832 kg CO_2 /4 months	$1,200/yr

Dynamic Power Conditioner (DPC)

This project demonstrates the use of the latest advances in power electronics to mitigate the cause of high neutral currents and provide several power quality benefits by using actively-controlled real and reactive power injection and absorption. The project uses energy storage devices and controls to provide dynamic phase balancing, voltage control, harmonics cancellation, sag mitigation, and power factor control while fostering steady state operations, such as injection and absorption of real and reactive power under scheduled duty cycles or external triggers.

Benefits

- The project indicated that using a DPC solely for phase balancing is currently neither practical nor cost-effective. However, if a BESS was installed to address a traditional energy storage use case, utilizing an inverter capable of phase balancing could reduce O&M costs by reducing or even eliminating the need for field crews to perform manual phase balancing operations.
- Using an inverter capable of phase balancing can potentially decrease the energy footprint requirement of a BESS and, as a result, the overall BESS cost. In certain situations, the inverter can potentially be added to an existing BESS via a firmware update.
- In early 2020, SCE's DPC project consulting engineer delivered a presentation on the project at the DISTRIBUTECH International Conference, an event that addresses technologies related to electricity delivery

automation and control systems, renewable energy integration, transmission and distribution system operation and reliability, and other key industry topics. This provided an opportunity for SCE to share information on the project and technology with interested stakeholders across the electric industry from utilities, energy service providers, federal power agencies, commercial and industrial electricity end-users, and additional industry organizations. SCE also presented at an Energy Storage Association symposium.

Quantitative Benefits Summary

	Measurement Area
	Presentations at Major Industry Events
Dynamic Power Conditioner	2

DC Fast Charging Demonstration

As EV adoption continues to accelerate and charging levels increase, it is important to understand how direct current (DC) fast EV chargers will impact the grid in terms of power quality, which was the intent of this project. The impact includes many factors such as harmonics, power factor, demand, energy, and efficiency.

Benefits

- Through project testing, SCE identified a fast charger type that was overly sensitive to voltage transients that were within the limits set by the SAE J2894 standard. This caused the charger to drop the current draw on one of the grid electrical phases and shift high current onto the neutral phase. This condition could result in distorted service to other grid customers and could have resulted in injury or death at each of the affected fast charge station sites. With over 7,000 DC fast chargers currently in service in California alone,[36] there are potentially nearly 400,000 charging sessions at DC fast chargers in California per year.[37] Even if this is a low-probability event, it could lead to injuring an EV driver. SCE alerted the manufacturer, which resolved the issue. As a result of this project, all charger manufacturers have now been asked to ensure their products meet the SAE J2894 standard. This standard is incorporated into SCE's Charge Ready program requirements.
- The project team encouraged the adoption of a more comprehensive specification for current total harmonic distortion limits defined by power level category, rather than a single defined limit for all SAE J1772 power levels. SCE's role helped to focus scrutiny in certain harmonic sectors and better describe potentially adverse impact levels.
- This project facilitates the installation and operation of DC fast chargers. The increased proliferation of fast chargers helps with the replacement of gasoline and diesel vehicles with electric vehicles. The project can help to scale SCE grid upgrades and EV charging infrastructure deployments.

Quantitative Benefits Summary

	Measurement Areas	
	Charging Sessions Made Safer	Standards Strengthened
DC Fast Charging	400,000/yr	1

[36] https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/electric-vehicle
[37] See Appendix B.

Integrated Grid Project (IGP) – Field Demonstration

The project demonstrated, field tested, and measured innovative technologies that emerged from the design phase of the IGP that address the impacts of DERs owned by both third parties and the utility. The objectives were to demonstrate the next generation grid infrastructure to improve the management, operation, and optimization of DERs on SCE's system. The results will help determine the controls and protocols needed to manage DERs, how to optimally manage an integrated distribution system to provide safe, reliable, affordable service, and how to validate locational value of DERs and understand their impacts to future utility investments. A subproject of the demonstration, EASE, was selected by SEPA as the 2022 SEPA Utility Transformation Project of the Year.[38]

Benefits

- Federal, California, and partner funds resulted in a total of $2.30 spent for each $1 of EPIC funding; combined value of the EPIC dollars and other funding was approximately $48 million.
- Distribution upgrades deferred, expecting to defer approximately $788 million through 2045 on capacity upgrades.[39]
- Incentivized customers to provide grid services and bid into the energy market – improving customer ROI on DERs ($462/year for EASE DSO market participants).
- Shared knowledge at 25 different external forums.
- Published two papers on estimating behind-the-meter solar power.[40]

Quantitative Benefits Summary

	Measurement Areas			
	Follow-on Funding	Customer ROI	Distribution Upgrades Deferred	External Knowledge Sharing
IGP	$2.30/$1 of EPIC funding	$462/yr	$788 million through 2045	16 presentations, 2 papers

VII. EPIC 3

Cybersecurity for Industrial Control Systems (AC/DZ) (Still in Progress)

As the frequency and sophistication of cyberattacks increase, it is critical for grid operators to be proactive to quickly identify, respond to, and mitigate threats to industrial control systems (ICS). This project will demonstrate, in a lab setting, the ability to deploy adaptive security controls and dynamically re-zone operational data networks while the ICS is either under cyberattack or subject to an increased threat level. Building on the work done in the CES21 Machine-Machine Automated Threat Response, this project will leverage machine-language threat intelligence techniques to determine the value and impact of dynamic response in the face of an attack. This project will

[38] https://sepapower.org/knowledge/sepa-announces-2022-utility-transformation-award-winners/

[39] Electric Access System Enhancement (EASE) Assessment of a Distributed Energy Resource Management System for Enabling Dynamic Hosting Capacity, pp. 55-56, 64-65.

[40] Association Rule Mining for Localizing Solar Power in Different Distribution Grid Feeders, IEEE Transactions on Smart Grid Vol12 Issue 3, 2021. Bilal Saleem, Yang Weng, Frank M Gonzales.
Mitigation of Grid Susceptibility Caused by Behind-the-meter Solar Generation, 2020 IEEE Conference on Technologies for Sustainability (SusTech). Michael Balestrieri, Anthony James, Matthew Kedis, Frank M Gonzales.

leverage the Simulation Engine and Physical Test Bed built under the CES-21 program to demonstrate how dynamic zoning and zone-specific cybersecurity controls (e.g., network white-listing, firewall rules, intrusion prevention engines, etc.) might be manipulated in order to contain or thwart a cyberattack.

Benefits

- Project results will help reduce the expense of building and integrating a commercial system into SCE's cybersecurity suite, which SCE's Risk Assessment and Mitigation Phase (RAMP) filing estimated vary from over $200,000 (with no impact to service or data) to over $80 million.[41]
- The results of AC/DZ may be used by the Department of Energy and National Labs to support Rapid Attack Detection, Isolation and Characterization Systems (RADICS) style events[42] by improving and making more realistic utility response options to attack scenarios and grid islanding procedures. This project could help to inform future NERC standards on best practices for informational disconnect of substations during emergency conditions.
- The project will help to increase safety by reducing the risk of injury from a cyberattack where an adversary obtains control of grid assets and causes harm to the electric grid. SCE's RAMP filing identifies the potential for serious injury or fatality in this scenario.

Quantitative Benefits Summary

	Measurement Area
	Potential Avoided Cyber Attack Cost
AC/DZ	$200,000 - $80 million per event

Distributed Cyber Threat Analysis Collaboration (DCTAC)

As the number of malicious actors and threat vectors multiply, private entities are increasingly responsible for collecting, analyzing, and disseminating critical threat intelligence in real-time. This project builds on findings from the California Energy Systems for the 21st Century (CES-21) project to demonstrate the ability to improve collaboration by standardizing electric utility cybersecurity threat analysis and information exchange. Improved analysis and communications through a DCTAC framework will help to shorten the response time to cyber-compromise of the grid. The project focused on documenting and refining intelligence workflows, both incoming and outgoing, standardizing and automating data processes, as well as providing enhancements to the governing body.

Benefits

- Assuming broad adoption, DCTAC could lead to the reduction of compromises of SCE cybersecurity controls (currently estimated at 25 events/year)[43] through early warning by the industry community and reduce the 16% of events that lead to significant cyber-event outcomes.[44]
- This project has the potential to improve reliability by shortening the time required to share cyber incident information between internal and external groups. The largest risk of a successful cyberattack to the grid involves malware that infiltrates the ICS and operates for a length of time, spreading like a cancer. This

[41] See Chapter 6 of SCE's 2018 Risk Assessment and Mitigation Phase Report, pp. 6.14 – 6.19.
[42] This is the "black start" grid attack scenario funded by DARPA, the Defense Advanced Research Projects Agency.
[43] See Chapter 6 of SCE's 2018 Risk Assessment and Mitigation Phase Report, pp. 6.14 – 6.19
[44] See Chapter 6 of SCE's 2018 Risk Assessment and Mitigation Phase Report, pp. 6.14 – 6.19

project demonstrates how to effectively protect our modernized electric system against these types of cyberattacks by facilitating collaboration across the Commission, federal government agencies and industry.

- The results of this demonstration will not only benefit SCE and other project participants, but will also support the development and/or refinement of standards through our coordination with OASIS, a nonprofit consortium that drives the development, convergence and adoption of open standards for the global information society.

Quantitative Benefits Summary

	Measurement Areas	
	Potential Reduction of Compromises of SCE Cybersecurity Controls	**Reduction in Probability of Cyber Event that Leads to Significant Negative Outcome**
DCTAC	Up to 25/year	Up to 16%

Advanced Comprehensive Hazards Tool (Still in Progress)

SCE's grid infrastructure faces a large and growing number of natural, physical hazards such as earthquakes and increases in extreme weather events driven by climate change. However, SCE's hazard risk assessment capabilities are fragmented by disparate data sources required for vulnerability analysis. This necessitates SCE personnel having to access multiple tools to develop a comprehensive understanding of these disparate hazards, which could impair SCE's ability to assess these risks from an integrated and comprehensive standpoint. This project will demonstrate the use of models for vulnerability and risk assessment using asset information, fragility analysis, and natural hazard data to enable identification of high hazard areas, asset specific vulnerabilities, and the impact of potential mitigations on overall grid resilience.

Benefits

- This project's tool will enable cost reductions through more accurate and targeted planning based on an improved understanding of specific vulnerabilities and the impacts of potential SCE mitigation responses. The current estimated repair and recovery rate from a seismic event based on the repair rate from the Ridgecrest Earthquake sequence is 30 man-hours per repair needed to fully restore a distribution circuit to as-built conditions. Moreover, there may be multiple necessary repairs per distribution circuit depending on the intensity of the ground acceleration. This tool could help SCE harden the grid where hazards are most likely to occur and reduce the repair frequencies and durations.
- The tool being demonstrated as part of this project will improve the Commission's and SCE's understanding of electric system vulnerabilities to natural hazard events by assisting with risk assessments and identifying grid vulnerabilities that can be documented with SCE's future vulnerability assessment filings.

Quantitative Benefits Summary

	Measurement Area
	Reduction in Repair and Recovery Rate
Advanced Comprehensive Hazards Tool	Reduction of number of repairs and length of each repair necessary, currently 30 man-hours per repair.

SA-3 Phase III Field Demonstration

SCE's current transmission-level substation automation systems are based on legacy technologies, which limits SCE's choice of products and flexibility to use products from a variety of vendors together in the same substation automation system. This project builds on the finding of the SA-3 Lab Demonstration in EPIC 1 and the systems intelligence and situational awareness project in EPIC 2. The project seeks to complete the identification and evaluation of components needed to demonstrate a fully digital substation that provides greater flexibility by utilizing open standards, while enabling IP-connectivity to the substation and maintaining compliance with cybersecurity requirements. This connected system enables remote device monitoring, data collection, and automated reporting tools for compliance.

Benefits

- The project may reduce costs, because IEC 61850 enables standardization and interoperability, which allows SCE to choose best-in-breed devices and stimulates market competition. Further, SCE estimates potential cost savings of 10-20% on digital substations using process bus technology, each of which costs approximately $2-$3 million. Because SCE performs relay replacements for 20-30 substations annually, this could potentially result in cost savings of $9.4 million per year.[45]
- Through the project, the team found various incompatibilities among device manufacturers utilizing standards-based communications. This has resulted in product updates from various product vendors.
- Presented lessons learned at DISTRIBUTECH 2018.

Quantitative Benefits Summary

	Measurement Area	
	Cost Reduction	**External Knowledge Sharing**
SA-III Phase 3 Demonstration	$9.4 million/year	1 presentation

Storage-Based Distribution DC Link (Still in Progress)

Current methods of managing line loading are inflexible and challenging to execute (e.g., operating parallel/tie switches). This project will demonstrate the potential for a DC Link to provide SCE grid operators with a tool to manage circuit loads between two distribution circuits in a controlled manner, which could improve reliability and enable higher amounts of renewables integration. Additionally, a connected battery system would supplement the amount of power transfer to either circuit. In a controlled lab environment, SCE's team is evaluating a storage-based DC link's ability to transfer load from one circuit to an adjacent circuit, as well as discharge a single battery energy storage system (BESS) onto one or both circuits to alleviate an overload condition.

Benefits

- This project could reduce costs, because a reduced number of switching operations made possible by the DC link would reduce wear and tear on switches and switch operator equipment that translates into lower repair outage costs. This system could also help to defer capacity-driven capital upgrades. Also, DER hosting capacity could be increased by routing power in a controlled manner between two circuits.

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[45] $2.5M for a substation relay replacement project (range of $2-$3M) x 15% cost reduction (10% - 20%) x 25 substations per year (range of 20-30) = $9.375 million.

- Project results could increase safety by reducing the number of switching operations, which lowers the exposure of SCE employees to potential switching-caused injuries. Further, the technology could reduce the number of wire downs and transformer failures caused by overloaded DER-heavy circuits as DERs proliferate across the system.
- Presented at DISTRIBUTECH 2020.

Quantitative Benefits Summary

	Measurement Area
	External Knowledge Sharing
Storage-Based DC Link	1 presentation

Smart City Demonstration (Still in Progress)

Utility-managed in front-of-the meter (IFOM) microgrids have the potential to enhance resiliency while maintaining safety and reliability on targeted portions of the electric system by enabling islanding during outages. This project will demonstrate a Microgrid Control System (MCS) in partnership with a disadvantaged community to manage DERs and loads for essential/critical facilities during outages. The planned and unplanned outages will be simulated to test microgrid capabilities.

Benefits

- This project has the potential to reduce customer demand charges and the need for distribution infrastructure upgrades by reducing peak load using the microgrid to supply local load when needed.
- The project has complementary environmental benefits, because a clean energy and storage-based microgrid can replace gas-burning generators that emit GHGs. Smart City will be deployed in an underserved community that is heavily affected by pollution, with a CalEnviroScreen 4.0 score as high as the 96th percentile.[46]
- Microgrids improve reliability and resiliency by decreasing the number of outages through temporary islanding. This could reduce the need for outages during PSPS events (this caused 105 million total Customer Minutes of Interruption in 2021).[47]
- Project results could improve the ability to create powered community shelter locations during PSPS and other events, which is especially important for protecting our most vulnerable customers in disadvantaged communities.
- According to South Coast Air Quality Management District (SCAQMD), one 750 HP/500 kW diesel generator emits on average 544 pounds of CO_2 per hour. The microgrid would remove the need for this diesel generator.
- Knowledge shared externally at DISTRIBUTECH 2022, as well as at 2020 EPIC/PICG conference on PSPS and 2020 EPIC/PICG conference on Equity/Disadvantaged Communities.

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[46] https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40

[47] https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-and-enforcement-division/meeting-documents/psps-briefings-february-2022/sce-psps-briefing-feb-2022.pdf

Quantitative Benefits Summary

	Measurement Area		
	Emissions Reduction	**Resiliency Improvement**	**External Knowledge Sharing**
Smart City Demonstration	Will help underserved community with CalEnviroScreen score in the 96th percentile.	Potential to mitigate Public Safety Power Shutoffs that caused 105 million total CMI in 2021.	3

Control & Protection for Microgrids and Virtual Power Plants (Still in Progress)

The purpose of this project is to specify and procure a microgrid controller system and microgrid infrastructure like synchronizing circuit breakers, relays, meters, etc. for testing and validation within a lab microgrid testbed. The testbed allows for automatic testing, data processing for machine learning analysis, and simulation of various microgrid modes and scenarios.

Benefits

- Microgrids improve reliability and resiliency by decreasing the number of outages through temporary islanding. This could reduce the need for outages during PSPS events (105 million total Customer Minutes of Interruption in 2021).[48]
- According to SCAQMD, one 750-HP/500-kW diesel generator emits on average of 544 pounds of CO2 per hour. The microgrid could remove the need for the diesel generator.[49]
- Presented at DISTRIBUTECH 2020 and a 2022 forum at Cal State University, Northridge.

Quantitative Benefits Summary

	Measurement Areas		
	GHG Reduction	**Resiliency Improvement**	**Knowledge Sharing**
Control and Protection for Microgrids	Removes need for diesel generators, which emit 544 lb of CO_2/hour	Potential to mitigate Public Safety Power Shutoffs that caused 105 million total CMI in 2021.	2 external presentations

Distributed Energy Resources Dynamic Integration Demonstration (Still in Progress)

A crucial technical challenge for supporting high DER penetration that has not been satisfactorily addressed is feeder protection system impacts. This project will perform control and power hardware-in-the-loop simulations and data testing, including inverter configuration and settings for optimal protection and operation of feeder protection relays under high DER penetration. The project will also evaluate the adverse interaction between inverters and

[48] https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-and-enforcement-division/meeting-documents/psps-briefings-february-2022/sce-psps-briefing-feb-2022.pdf.
[49] http://www.aqmd.gov/docs/default-source/ceqa/handbook/emission-factors/off-road-mobile-source-emission-factors-(scenario-years-2007-2025).xls?sfvrsn=2.

their impacts on the protection system to better understand their impact on the protection system, owing to the interaction between inverter and non-inverter based DERs.

Benefits

- The project will demonstrate integration of high volumes of behind-the-meter inverter-based DERs, focusing on preserving the safety and reliability of distribution feeders with significant solar PV generation.
- An in-depth understanding of the modeling and simulation of such projects is limited in the vendors' domain and will be extensively explored in this project. Potential market development opportunities in this area will be highlighted.
- Dissemination of knowledge gained from this project will help other utilities, developers, and customers who are facing these challenges with integrating DERs.
- Presented at Hybrid and EV Technologies Symposium in 2022 and IEEE Green Energy and Smart Systems Conference in 2020.

Quantitative Benefits Summary

	Measurement Areas
	Knowledge Sharing
DER Dynamics Integration	2 external presentations

Vehicle-to-Grid Integration Using Onboard Inverter

Vehicle-to-Grid (V2G) technology offers the potential to discharge EV batteries to the grid to provide valuable grid services and help customers manage their energy costs. This project will demonstrate methods for V2G-capable EVs and EV supply equipment (EVSE) to grid interconnect and charge/discharge in coordination with customer, utility and operational requirements. The project will use newly-proposed Rule 21 V2G interconnection requirements, interface with major automakers (both light and heavy-duty), charger and EVSE makers, aggregators and control interfaces, and standards organizations on both infrastructure and automotive side, to demonstrate that EVs can interconnect to utility systems and become resources serving both utility and customer interests. The project will rely on utility and third-party controls to accomplish this goal.

Benefits

- V2G can deliver on-demand load management locally or systemwide. Charging of light-duty vehicles is expected to reach 6.9% of peak load by 2030. Proper control can mitigate acute system issues caused by bus/medium duty fleet charging (e.g., feeding the grid by turning off 100 buses at 150 kW can produce up to 15 MW of grid support when needed).
- The project will demonstrate a path for standards and certification agencies to certify products that can meet interconnection requirements. As automakers seek to maintain their self-certifying capacity and authority for vehicles, this project will demonstrate the types of systems that can be certified, qualifying them to proceed on a pathway for interconnection.
- This project will leverage EV batteries as a form of grid energy storage, which can reduce the impact of outages (e.g., a project participant's school bus battery pack has 156 kWh of usable energy and could provide resiliency service during outages) and help avoid outages altogether by helping to reduce overload conditions.

- V2G can enable EVs owners to better manage their electric usage. Moreover, to the extent EVs can be used to reduce load, this could help to defer or avoid additional distribution capacity and peak generation resources.

Quantitative Benefits Summary

	Measurement Areas	
	Customer Outage Mitigation	**Grid Support**
Vehicle-to-Grid Integration	One school bus battery has 156 kWh of usable energy for service during outages.	Reduction of up to 6.9% of peak load by 2030

Distributed Plug-in Electric Vehicle Charging Resources (Still in Progress)

Increasing levels of electricity demand from EV chargers has the potential to place additional strain on SCE's distribution infrastructure. This project will perform a lab demonstration (and potentially also a field demonstration) of fast charging integrated with energy storage to alleviate fast-charging impacts to the grid, potentially reduce customer demand charges, and explore the advantages and disadvantages of using new or used batteries for integrated energy storage applications.

Benefits

- This project plans to demonstrate the ability to shift EV charging load, which could reach 17% of peak load by 2030. The ability to shift charging from the evening peak to late night could reduce emissions by over 33%, while shifting from early morning to noon could reduce emissions by up to 73% due to the difference in CO_2 from grid power sources at different times.[50] At a future population of 26 million EVs, shifting load could save over 21,000 metric tons of CO_2 per year,[51] which equates to approximately $1.7 million in CO_2 equivalent (CO_2e) reduction benefits annually by 2030.[52]
- This project will potentially improve reliability by evaluating the energy storage system (ESS) controls needed to mitigate voltage issues on the system. Connection of such systems to SCE's Grid Management System adds a potentially valuable resource to the set of advanced tools available to manage the grid and avoid or defer capital upgrades (such as capacitor banks and other volt/VAR management devices).
- The project will use an ESS, which can help customer bill management by allowing them to charge the ESS when prices are lowest and then charge their cars from the ESS when needed. The use of an ESS can create a potential market for used EV batteries and provide the potential to earn V2G revenues without the complexity of V2G systems.

Quantitative Benefits Summary

	Measurement Area
	GHG Reduction
Distributed Plug-in EV Charging Resources	Over 21,000 metric tons of CO_2/year

[50] https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/comments/tier2/elec_update.pdf.
[51] See Appendix B.
[52] 21,594 MT CO2 x $78.02/CO2e MT (CEC 2030 Mid Case in 2019 IEPR) = $1,684,751.

Service and Distribution Center of the Future (Still in Progress)

The operation of large scale EV fleets has the potential to increase customer costs, driven by increased utility expenditures, due to higher power and energy and distribution capacity needs. As these fleets grow, pockets of concentrated load may develop, which can burden distribution systems. However, the grid could also benefit from the application of technology implemented to manage the charging system. This project will demonstrate a fleet service center or depot with large EV charging demands, supporting elements such as energy storage, PV, controlled (V1G) and bidirectional (V2G) EV charging with individual charger metering, and electrified space and water heating - all controlled by an innovative site energy management system to reduce the cost and improve the value of fleet electrification, while managing safe and reliable grid operations.

Benefits

- This project will demonstrate the potential for using controls and storage to manage load below an upgrade point, with the objective of reducing customer and utility costs. These costs vary, but have recently been measured between $7 million and $15 million.
- The site control system will also optimize charging load across the fleet to decrease the cost burden on the customer and provide the lowest fuel cost. The configuration of the project elements will show the potential benefit of managing a DC-based system integrating EV charging, energy storage and potential PV generation at the facility. Running loads directly off DC generated by PV could increase efficiency of integrating renewables on-site. The building electrification element shows the cost and emissions savings of switching from gas to electric and integrating controls with the facility to lower electric costs.
- This project helps influence market product development, such as microgrid control systems, stationary energy storage systems, smart charging systems, building management systems, EV submetering systems, fleet operations management systems, and electric utility distribution energy resource management systems.
- Coordinated charging can help drive increased electrification of medium-duty and bus fleets across SCE's service territory, as well as building electrification. SCE's Pathway 2045 envisions electrifying 900,000 medium-duty vehicles and 170,000 heavy-duty vehicles.[53] Replacement of those vehicles with electric vehicles could save almost 39,000,000 metric tons of CO_2 per year,[54] which equates to over $3 billion in CO_2e reduction benefits annually by 2030.[55]
- Presented at CEATI 2020

Quantitative Benefits Summary

	Measurement Areas		
	GHG Reduction	**Customer Cost Reduction**	**External Knowledge Sharing**
Service and Distribution Center of the Future	Potential reduction of 39,000,000 metric tons of CO_2/year (valued at over $3 billion annually)	$7 million - $15 million	1 presentation

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[53] https://www.edison.com/home/our-perspective/pathway-2045.html.

[54] See Appendix B.

[55] 38,859,869 MT CO2 x $78.02/CO2e MT (CEC 2030 Mid Case in 2019 IEPR) = $3,031,846,964.

Wildfire Prevention & Resiliency Technologies (Still in Progress)

The *Wildfire Prevention & Resilience Technologies* (WP&RT) project is demonstrating the latest advancements in hardware- and software-based solutions in wildfire prevention, detection and mitigation. WP&RT utilizes Machine Learning (ML) in two different applications. In a centralized application, waveform analytics aims to integrate grid data streams into ML algorithms that could detect potential failures before they happen. In a decentralized application, ML on edge devices could provide faster decision making for wildfire mitigation applications.

Benefits

- The analytics platform senses incipient issues and allows SCE to target its infrastructure replacement of equipment in imminent danger of failing and potentially igniting a wildfire.
- Distribution Waveform Analytics (DWA) may be able to alert operators to a potential failure before it happens in five of the currently projected High Fire Threat District (HFTD) ignition instances in 2022.[56]
- ML at the Edge will help expedite the remediation of high priority issues via faster identification of the issues.
- The analytics platform detects the signature of an ignition event for early warning. DWA may be able to alert operators to 30 currently projected potential ignition events in HFTD in 2022,[57] allowing for more immediate fire response and suppression efforts to occur before fires expand.
- Through reduction of manual patrols, ML at the Edge could reduce the impact of PSPS events to our customers, as service could be restored to some customers more quickly without the need for a manual patrol.

Quantitative Benefits Summary

	Measurement Areas	
	Ignition Reduction	Fire Mitigation
WP&RT	5 events/year	30 events caught early/year

Beyond Lithium-Ion Energy Storage Demo (Still in Progress)

This project will demonstrate one example of next-generation, pre-commercial, "beyond lithium-ion" energy storage technologies that have high probability of commercial viability but require real world field experience to reduce technology and adoption barriers on the path to commercialization.

Benefits

- Some new battery technologies are less prone to thermal runaway than lithium-ion, and some may use safer or more plentiful raw materials, which improves safety while reducing cost.
- 30 GW of utility-scale energy storage will be needed to support the state's policy goal in the next 25 years. Some non-lithium-ion batteries could be used for longer durations than lithium-ion, making them useful for mitigating long-duration PSPS events while also supporting base load.

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[56] See Appendix B, based on SME feedback connected to: https://www.sce.com/sites/default/files/AEM/Wildfire%20Mitigation%20Plan/2021/SCE_Q1_20210503.xlsx

[57] See Appendix B, based on SME feedback connected to: https://www.sce.com/sites/default/files/AEM/Wildfire%20Mitigation%20Plan/2021/SCE_Q1_20210503.xlsx

- Improved storage technologies may make microgrids more attractive and allow for longer lasting backup generation, power quality improvement, and fast ramping.
- Natural gas plants currently provide 46% of in-state generation. A cost-competitive long-duration storage technology could reduce the 60 million metric tons of CO_2e released in 2019 by the California electric sector by enabling the grid-integration of vastly higher amounts of DERs.

Quantitative Benefits Summary

	Measurement Area
	GHG Reduction
Beyond Lithium-Ion Energy Storage	Potential to reduce 60 million metric tons of CO2 released in 2019 by CA electric sector.

VIII. Conclusion

SCE's EPIC Program has delivered customer value by providing a means to test and evaluate the integration of pre-commercial or early commercial technologies, which are helping to advance the electric grid. SCE's EPIC Program provides a crucial path to market for promising technologies and examines how to mitigate environmental hazards from climate change, as well as emerging threats to the grid, such as cyber-attacks. SCE's EPIC projects have provided program-driven benefits with a focus on the guiding principles of safety, reliability and affordability, as well as providing complementary sources of value. SCE's projects have also provided benefits, as well as other sources of value. SCE looks forward to working with PG&E, SDG&E, the CEC, and Commission staff and interested stakeholders, especially disadvantaged communities on EPIC 4 to further coordinate and harmonize project metrics and analysis tools for the benefit of customers.

Appendix A

Working Benefits Framework

Working Benefits Framework

The following benefits analysis framework aligns with the mandatory guiding principle of EPIC, to provide ratepayer benefits within the CPUC-defined areas of increasing reliability, improving safety, increasing affordability, improving environmental sustainability, and improving equity. Because the EPIC program involves the demonstration and evaluation of pre-commercial technologies, benefits are dependent on both qualitative and quantitative factors. To capture the benefits of pre-commercial demonstrations' inherent knowledge and data seeking objectives, supplemental quantification and qualification can be attributed to the following benefit areas: Adoption of EPIC Technology, Effectiveness of Information Sharing and Technology Development Progress. The following measurement areas are the most closely-aligned of the benefits in D.13-11-025 Attachment 4, though in the future there may be additional benefits from Attachment 4 that may be applicable to EPIC projects.

Benefit Area	Measurement	Resources/Tools Applied
Reliability	1. Equipment service life extension 2. Outage number, frequency and duration reductions 3. Reduction in system and equipment failures 4. Improved reliability to DAC customers	• Final Reports • Internal Presentations • SME Estimates • Interruption Cost Estimate (ICE) Calculator • Various models
Safety	1. Worker safety improvement and hazard exposure reduction 2. Public safety improvement and hazard exposure reduction 3. Safety improvements targeted towards DAC	• Final Reports • Internal Presentations • SME Estimates • https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/light-duty-vehicle • Various models
Environmental Benefits	1. Habitat area disturbance reductions	• Final Reports • Internal Presentations • SME Estimates • https://www.californiadgstats.ca.gov/charts/

Benefit Area	Measurement	Resources/Tools Applied
	2. Reduce GHG emissions ($MMTCO_2e$) 3. DAC Residents impacted by reduced emissions	• CalEnviroscreen 4.0 • Various models
Economic Benefits	1. Maintain/reduce O&M costs 2. Maintain/reduce capital costs 3. Peak load reduction 4. Reduced cost of DER adoption 5. Reduced cost of DER adoption for DAC. 6. Avoided customer energy use 7. Follow-on funding to projects 8. Customer bill or interconnection savings 9. CO_2 equivalent savings	• Final Reports • Internal Presentations • SME Estimates • Various models
Effectiveness of Information Sharing	1. Number of industry sharing events/papers presented 2. Number of times reports are cited in scientific journals and trade publications for selected projects 3. Number of information sharing forums held	• Final Reports • Internal Presentations • External presentations • Other published papers • SME Estimates

Benefit Area	Measurement	Resources/Tools Applied
	4. Stakeholder attendance at workshops 5. Results provided to standard development organizations	
Adoption of EPIC Technology	1. EPIC project results referenced in regulatory proceedings 2. Number of technologies/use cases demonstrated, in direct use post-EPIC 3. Number of technologies included for funding in the GRC, or for which post-EPIC funding has otherwise formally been committed	
Technology Development Progress	1. Technology Readiness Level (TRL) Scale Assignment	

Appendix B

Benefits Report Calculations

"DWA Could Predict Early Warning Signs" and "DWA Could Detect Event" use SME input on whether DWA could either predict (and therefore prevent) an ignition or detect the ignition based on the driver. The columns with "2022" as header are the expected 2022 ignitions.

Utility	Southern California Edison Company	Notes:										
	Metric type	#	Ignition driver	DWA Could Predict Early Signs	DWA Could Detect Event	Are ignitions tracked for ignition driver? (yes / no)	2022	2022	2022	2022	2022	Unit(s)
Ignition - Distribution	1. Contact from object - Distribution	1.a.	Veg. contact- Distribution	Maybe	Yes	Yes	9	0	1	0	0	# ignitions
		1.b.	Animal contact- Distribution	No	Yes	Yes	16	0	1	2	0	# ignitions
		1.c.	Balloon contact- Distribution	No	Yes	Yes	14	0	1	3	0	# ignitions
		1.d.	Vehicle contact- Distribution	No	Yes	Yes	5	0	1	3	0	# ignitions
		1.e.	Other contact from object - Distribution	Maybe	Maybe	Yes	3	0	0	0	0	# ignitions
	2. Equipment / facility failure - Distribution	2.a.	Capacitor bank damage or failure- Distribution	Yes	Yes	Yes	0	0	0	0	0	# ignitions
		2.b.	Conductor damage or failure — Distribution	No	Yes	Yes	4	0	1	12	0	# ignitions
		2.c.	Fuse damage or failure - Distribution	Maybe	Yes	Yes	1	0	0	0	0	# ignitions
		2.d.	Lightning arrestor damage or failure- Distribution	Yes	Yes	Yes	1	0	0	0	0	# ignitions
		2.e.	Switch damage or failure- Distribution	Yes	Yes	Yes	6	0	0	0	0	# ignitions
		2.f.	Pole damage or failure - Distribution	No	No	Yes	1	0	0	0	0	# ignitions
		2.g.	Insulator and brushing damage or failure - Distribution	Maybe	Yes	Yes	4	0	0	0	0	# ignitions
		2.h.	Crossarm damage or failure - Distribution	No	No	Yes	0	0	0	0	0	# ignitions
		2.i.	Voltage regulator / booster damage or failure - Distribution	Maybe	Yes	Yes	0	0	0	0	0	# ignitions
		2.j.	Recloser damage or failure - Distribution	Yes	Yes	Yes	0	0	0	0	0	# ignitions
		2.k.	Anchor / guy damage or failure - Distribution	No	No	Yes	0	0	0	0	0	# ignitions
		2.l.	Sectionalizer damage or failure - Distribution	Yes	Yes	Yes	0	0	0	0	0	# ignitions
		2.m.	Connection device damage or failure - Distribution	Maybe	Yes	Yes	2	0	0	1	0	# ignitions
		2.n.	Transformer damage or failure - Distribution	Yes	Yes	Yes	7	0	0	0	0	# ignitions
		2.o.	Other - Distribution	Maybe	Maybe	Yes	3	0	0	1	0	# ignitions

	3. Wire-to-wire contact - Distribution	3.a.	Wire-to-wire contact / contamination- Distribution	Yes	Yes	Yes	3	0	0	0	0	# ignitions
	4. Contamination - Distribution	4.a.	Contamination - Distribution	No	No	Yes	1	0	0	0	0	# ignitions
	5. Utility work / Operation	5.a.	Utility work / Operation	No	No	No	0	0	0	0	0	# ignitions
	6. Vandalism / Theft - Distribution	6.a.	Vandalism / Theft - Distribution	No	No	Yes	1	0	0	3	0	# ignitions
	7. Other- Distribution	7.a.	All Other- Distribution	No	No	Yes	1	0	0	0	0	# ignitions
	8. Unknown- Distribution	8.a.	Unknown - Distribution	No	No	Yes	8	0	0	0	0	# ignitions
Ignition - Transmission	9. Contact from object - Transmission	9.a.	Veg. contact- Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		9.b.	Animal contact- Transmission	No	No	Yes	0	0	0	1	0	# ignitions
		9.c.	Balloon contact- Transmission	No	No	Yes	1	0	0	0	0	# ignitions
		9.d.	Vehicle contact- Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		9.e.	Other contact from object - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
	10. Equipment / facility failure - Transmission	10.a.	Capacitor bank damage or failure- Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		10.b.	Conductor damage or failure — Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		10.c.	Fuse damage or failure - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		10.d.	Lightning arrestor damage or failure- Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		10.e.	Switch damage or failure- Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		10.f.	Pole damage or failure - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		10.g.	Insulator and brushing damage or failure - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		10.h.	Crossarm damage or failure - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		10.i.	Voltage regulator / booster damage or failure - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		10.j.	Recloser damage or failure - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
		10.k.	Anchor / guy damage or failure - Transmission	No	No	Yes	0	0	0	0	0	# ignitions

	10.l.	Sectionalizer damage or failure - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
	10.m.	Connection device damage or failure - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
	10.n.	Transformer damage or failure - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
	10.o.	Other - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
11. Wire-to-wire contact - Transmission	11.a.	Wire-to-wire contact / contamination- Transmission	No	No	Yes	0	0	0	0	0	# ignitions
12. Contamination - Transmission	12.a.	Contamination - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
13. Utility work / Operation	13.a.	Utility work / Operation	No	No	No	0	0	0	0	0	# ignitions
14. Vandalism / Theft - Transmission	14.a.	Vandalism / Theft - Transmission	No	No	Yes	0	0	0	0	0	# ignitions
15. Other- Transmission	15.a.	All Other- Transmission	No	No	Yes	0	0	0	0	0	# ignitions
16. Unknown- Transmission	16.a.	Unknown - Transmission	No	No	Yes	0	0	0	0	0	# ignitions

Yearly MW installed 2019-2021	10% increase	To Kilowatts	Number of 5 kW systems that displace 1 metric ton of CO2/yr	$/CO2e MT	Savings
1,311	131	131,149	26,230	78.02	2,046,449.00

https://www.californiadgstats.ca.gov/charts/

% of EVs Charged at Home	% of Non-home chargers DC Fast Chargers	EVs in Service	EVs Charged at Fast Chargers	Weekly Charging Events at Fast Chargers
90%	9%	827,760	7,498	389,893

https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/light-duty-vehicle

% of EVs charged at home a	EVs in service by 2045	Miles/Car/Yr	kWh/mile	MJ/kWh	mgCO2/MJ	mg/metric ton	Efficiency gain for L2 charging
90%	26,000,000.00	12,000	0.32	3.6	82.3	1,000,000,000.00	15%

Cars charging in L1 at home	mgCO2 per car per yea	mgCO2 for ca	Metric tons CO2 for cars charged in L1 at home in 2045	15% efficiency gain from L2 charging
23,400,000.00	**1,137,715**	**2.6623E+13**	**26,622.54**	**3,993.38**

EVs in service by 2045	Miles/Car/Yr	kWh/mile	MJ/kWh	mgCO2/MJ	mg/metric ton	Efficiency gain for L2 charging
26,000,000.00	12,000	0.32	3.6	82.3	1,000,000,000.00	15%

mgCO2 per car per year	mgCO2 for cars charged in 2045	Metric tons CO2 for cars charged in 2045	73% CO2 reduction through Load Shifting
1,137,715	2.95806E+13	29,580.60	21,593.83

Heavy Duty Vehicles	Miles Per Year/Truck	kWh/mile	kWh/yr	mJ/kWh	EER	Diesel mg CO2/MJ	Grid Mg CO2/MJ	Avoided Metric Tons of CO2
170,000.00	60,000	2.00	20,400,000,000.00	3.60	5.00	80.36	51.18	25,749,532.80

Medium Duty Vehicle	Miles Per Year/Truck	kWh/mile	kWh/yr	mJ/kWh	EER	Gasoline mgCO2/MJ	Avoided Metric Tons of CO2
900,000.00	15,000	1	13,500,000,000.00	3.60	3.6	89.15	13,110,336.00

Total Avoided Metric Tons of CO2
38,859,869

$ In Millions

Circuits with Existing Automation

$ In Millions	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
GMS: CMI due to 10 min switching time															
CMI Reduction (minutes)		0.00	0.00	0.00	0.00	36,579,949	36,579,949	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209
CMI Reduction (minutes, in millions)		0.00	0.00	0.00	0.00	36.58	36.58	38.51	38.51	38.51	38.51	38.51	38.51	38.51	38.51
CMI Value (PV)		0.00	0.00	0.00	0.00	$ 72.35	$ 67.28	$ 65.81	$ 61.15	$ 56.86	$ 52.89	$ 49.23	$ 45.80	$ 42.60	$ 39.61
GMS: Avoided CMI increase resulting from DER adoption															
CMI Reduction (minutes)		0.00	0.00	0.00	-	-	-	10,914,021	13,071,796	14,895,896	17,407,484	19,919,073	19,919,073	19,919,073	19,919,073
CMI Reduction (minutes, in millions)		0.00	0.00	0.00	0.00	0.00	0.00	10.91	13.07	14.90	17.41	19.92	19.92	19.92	19.92
CMI Value (PV)		0.00	0.00	0.00	0.00	$ -	$ -	$ 18.65	$ 20.76	$ 21.99	$ 23.91	$ 25.47	$ 23.69	$ 22.04	$ 20.49

$ In Millions	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
GMS: CMI due to 10 min switching time														
CMI Reduction (minutes)	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209	38,505,209
CMI Reduction (minutes, in millions)	38.51	38.51	38.51	38.51	38.51	38.51	38.51	38.51	38.51	38.51	38.51	38.51	38.51	38.51
CMI Value (PV)	$ 36.81	$ 34.20	$ 31.77	$ 29.50	$ 27.40	$ 25.45	$ 23.64	$ 21.95	$ 20.40	$ 18.95	$ 17.62	$ 16.37	$ 15.22	$ 14.15
GMS: Avoided CMI increase resulting from DER adoption														
CMI Reduction (minutes)	19,919,073	19,919,073	19,919,073	19,919,073	19,919,073	19,919,073	19,919,073	19,919,073	19,919,073	19,919,073	19,919,073	19,919,073	19,919,073	19,919,073
CMI Reduction (minutes, in millions)	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92
CMI Value (PV)	$ 19.04	$ 17.69	$ 16.43	$ 15.26	$ 14.17	$ 13.16	$ 12.23	$ 11.36	$ 10.55	$ 9.80	$ 9.11	$ 8.47	$ 7.87	$ 7.32

Escalation Rates

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
WACC	10%															
Discount Factor	1.00	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39	0.35	0.32	0.29	0.26	0.24
Escalation Rates																
Capital	1.00	1.04	1.07	1.09	1.11	1.14	1.16	1.18	1.21	1.23	1.25	1.28	1.30	1.33	1.36	1.38
O&M	1.00	1.01	1.03	1.04	1.06	1.08	1.10	1.12	1.14	1.17	1.19	1.21	1.24	1.26	1.28	1.31
JPGDP	1.00	1.02	1.05	1.08	1.10	1.13	1.15	1.18	1.20	1.23	1.26	1.29	1.32	1.35	1.38	1.41
CMI Value ($/CMI)	$ 2.63	$ 2.69	$ 2.76	$ 2.83	$ 2.90	$ 2.96	$ 3.03	$ 3.09	$ 3.17	$ 3.24	$ 3.32	$ 3.39	$ 3.47	$ 3.55	$ 3.63	$ 3.71

	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
WACC															
Discount Factor	0.22	0.20	0.18	0.16	0.15	0.14	0.12	0.11	0.10	0.09	0.08	0.08	0.07	0.06	0.06
Escalation Rates															
Capital	1.41	1.44	1.47	1.50	1.53	1.56	1.59	1.62	1.65	1.68	1.72	1.75	1.79	1.82	1.86
O&M	1.34	1.36	1.39	1.42	1.44	1.47	1.50	1.53	1.56	1.59	1.62	1.65	1.68	1.72	1.75
JPGDP	1.44	1.47	1.50	1.54	1.57	1.60	1.64	1.68	1.71	1.75	1.79	1.83	1.87	1.92	1.96
CMI Value ($/CMI)	$ 3.79	$ 3.87	$ 3.96	$ 4.04	$ 4.13	$ 4.22	$ 4.31	$ 4.41	$ 4.51	$ 4.61	$ 4.71	$ 4.82	$ 4.93	$ 5.04	$ 5.15

Overhead Rate

GMS	1%

Contingency Rate

GMS	20%

Franchise Fees & Uncollectables

FF&U Gross-up Factor	1.16051%
FF&U Factor	1.14720%

Other Assumptions

DER Impacts Occur with Gen >3MW.
Reliability improvements reflect Grid DA deployments through 2020.
Base DERMS completion 2024.
ADMS Assisted Switching Completion 2022.

Appendix B

Acronyms and Abbreviations

ACRONYM	DEFINITION
AB	Assembly Bill
AC	Alternate Current
ADMS	Advanced Distribution Management System
APS	Adaptive Protection System
AUPEC	Australasian Universities Power Engineering Conference
B2B	back-to-back
BESS	battery energy storage system
CAISO	California Independent System Operator
CAVA	Climate Adaptation Vulnerability Assessment
CEC	California Energy Commission
CMS	Energy Storage Constraint Management
CPC	centralized protection control
CPRE	Annual Conference for Protective Relay Engineers
CPUC	California Public Utilities Commission
CR	Coupling Relay
CRM	Community Resiliency Metric
DAC	Disadvantaged Community
DACAG	Disadvantaged Communities Advisory Group
DART	Days Away Restricted Duty
DC	Direct Current
DER	Distributed Energy Resource
DERMS	Distributed Energy Resources Management Systems
DFR	Digital Fault Recording
DG	Distributed Generation
DRIVE	Development of Rates and Infrastructure for Vehicle Electrification
DRP	Distributed Resource Planning
DVVC	Distribution Volt/VAR Control
EI2	Energy Internet and Energy System Integration
EO	Executive Order
EPIC	Energy Program Investment Charge
EPRI	Electric Power Research Institute
ERCOT	Electric Reliability Council of Texas
EUROCON	European Conference
EV	Electric Vehicle
FAN	Field Area Network
FLISR	fault location, isolation and service restoration
GHG	Greenhouse Gas
GMS	Grid Management System
GRC	General Rate Case
HVRT	High Voltage Ride Through
I&CPS Asia	Industrial and Commercial Power System Asia
IBR	Inverter Based Resource
IBR	inverter-based resources
IEEE	The Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IOU	Investor-Owned Utility

IP	Intellectual Property
IPAPS	International Conference on Protection and Automation of Power Systems
ISGT Asia	Innovative Smart Grid Technologies - Asia
ISO/RTO	Independent System Operators/Regional Transmission Organizations
LDES	long duration energy storage
LVRT	Low Voltage Ride Through
MAIFI	Momentary Average Interruption Frequency Index
MPCC	multiple-points-of-common-coupling
NoLESS	non-lithium energy storage systems
OECC	Opto-Electronics and Communications Conference
OIR	Order Instituting Rulemaking
OPD	Open Phase Detection
OT	Operational Technology
OTSS	optical time slice switching
OU	Organizational Unit
PG&E	Pacific Gas and Electric Company
PGC	Photonics Global Conference
PICG	Policy + Innovation Coordination Group
PLL	planned loading limit
PNNL	Pacific Northwest National Laboratory
POWERCON	International Conference on Power System Technology
PSPS	Public Safety Power Shutoff
RAP	Research Administration Plan
RFP	Request for Proposal
RPA	Relay Protection and Automation
SAE	Society of Automotive Engineering
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SB	Senate Bill
SCADA	Supervisory Control and Data Acquisition
SCE	Southern California Edison Company
SDG&E	San Diego Gas and Electric Company
SF6	Sulphur Hexafluoride
T&D	Transmission and Distribution
UNM	University of New Mexico
VGI	Vehicle Grid Integration
ZFMA	Z-Factor Memorandum Account

Appendix C

Stakeholder Engagement

Stakeholder Engagement

Overview

The development of SCE's EPIC 4 Investment Plan involved extensive stakeholder feedback, please see X Section for additional details. The Commission requires the Public Administrators to hold at least two public stakeholder workshops during the development and execution of the Administrator's respective Plans. The Utilities held four joint public engagements, two public workshops and two workshops targeting Disadvantaged Communities (DACs).

In general, stakeholders' comments during these engagements focused on general programmatic related information, as well as technology gaps and priorities. However, SCE found two comments from workshop stakeholders particularly useful to helping develop the EPIC 4 Investment Plan. These comments include:

- The Disadvantaged Communities Advisory Group (DACAG) encouraged the Utilities to review their guiding principles to determine whether they'd be applicable to the Utilities' EPIC 4 Investment Plans. SCE has applied the DACAG guiding principles to the EPIC 4 Investment Plan by creating an equity matrix showing direct and indirect benefits to DACs from the Plan's Strategic Initiatives, please see Summary of Stakeholder Engagement in Investment Planning Process Section, Table 2 Equity Matrix for additional details.[1]
- In the August 29, 2022 Public Workshop, an energy services company from the vendor community raised the concept of a utility owned communication platform for DER owners. SCE recognizes the importance of communications to further optimize DERs on the grid and has incorporated this feedback into the EPIC 4 Investment Plan. SCE has identified the Energy Management Foundational Technologies as the most appropriate initiative to cover this communications platform for DER owners. SCE plans to cover different aspects of DER communications under the Localized Edge Control and Customer Load Flexibility Research Topics.

The workshop slide presentations, as well as the recordings of the DAC workshops are available on SCE's EPIC web page.[2] A summary of stakeholder feedback from each Workshop is provided below:

<u>Joint Utilities EPIC DAC Workshop, June 21, 2022</u>

1. Overview of Electric Program Investment Charge (EPIC)

1.1. Overview

• California statewide program funded by ratepayers that allows Utilities and CEC to invest and pursue innovative energy solutions focused on increased safety, improved affordability, greater reliability, environmental sustainability, and equity

[1] See EPIC Investment Plan at p. 12.
[2] https://www.sce.com/regulatory.

• Three CPUC-designated work categories for EPIC are Applied Research & Development, Technology Demonstration & Deployment, and Market Facilitation

• Utilities can work only in the Technology Demonstration and Deployment category (not permanent commercial deployments but proof of concept demonstrations to determine the value proposition for emerging innovations)

1.2. Scope Range and Constraints for IOU EPIC Projects

• Flexibility to demonstrate a wide range of technology solutions

• CPUC-designated constraints *(see Workshop ppt. slide #7 for a list of constraints)*

1.3. Funding Allocations for Project Work

• Funding allocation for five-year EPIC-4 cycle: 80% CEC, 20% IOUs

• Funding is broken down between the three IOUs in proportion to total revenue collection (see Workshop ppt. slide #8 for more details)

1.4. Implementation Process

• IOU EPIC-4 applications are due on Oct. 1, 2022

• Schedule is comprised of a series of activities specified by CPUC *(see Workshop ppt. slide #9 for details)*

• EPIC 4 applications will be designed around strategic initiatives and topics within those strategic initiatives (not individual projects); not all approved topics within approved strategic initiatives will have funding available, so they will require prioritization to determine which projects in support of the approved topics would proceed.

Examples of Past EPIC Projects with DAC Benefits

2.1. PG&E DAC Demonstration Benefits

2.1.1. Advanced Distributed Energy Resource Mgt Systems (DERMS) & Advanced Dist. Mgt. System (ADMS)

• A telemetry solution that solves the problem of high-cost connectivity of customer distributed energy resources of 1MW+ into the utility

• Previous cost could be up to $150,000 to connect per the mandate

• With the new system created under the EPIC program, the cost is significantly lower

• Connects into the grid operations center to ensure safe and reliable operations of the grid for larger types of DER

• One of the three demonstration sites is the Blue Lake Rancheria (BLR) in Humboldt County; BLR is a DAC with PV DER concerned about high cost of the state requirement for telemetry

2.1.2. System Harmonics for Power Quality Investigations

• Harmonics are disturbances to the flow of power causing negative impact on customer equipment

• Previous methods to address issues required placement of specialized equipment to collect, analyze and correct

• Smart meters allow for remote access to understand issues more quickly, avoids truck rolls, improving safety and customer experience

• Demonstration Sites - In Central Valley there are many DACs affected by harmonics thrown off by nearby solar farms, agriculture pumps, etc. Most of the project's meters are installed in these DAC areas to allow for more responsiveness in these areas

• Participant Question: Are the smart meters used for the demonstration the standard meters or are they retrofitted in their hardware/software? Answer: They are a newer, more capable version of the current generation smart meters; they can perform high quality analysis and recording and for the demonstration are added next to the current generation smart meter. In a deployment this newer type of smart meter would replace the current generation smart meter.

2.2. SDG&E DAC Demonstration Benefits

2.2.1. Demonstration of Multi-Purpose Mobile Battery Energy Storage System (MBESS)

• Determine the value proposition for MBESS in different use cases at different sites and determine a rationale for rotating the MBESS to alternative sites to maximize the use of the MBESS

• Encouraging the emergence of an MBESS supplier industry as it has been observed to be a fledgling industry

• Benefit areas of the project include: Peak Demand Reduction, Community Services & Climate Change, Grid Modernization & Resiliency, Economic *(see Workshop ppt. slide #17 for details)*

• Sample use cases of Support islanding in rural community to maintain critical loads; mobile battery serves as auxiliary resource during planned or unplanned outages

• Support community resource centers during public safety power shutoffs and other emergencies

• Participant Question: The mobile battery can be used for either cost reduction or GHG reduction and the current price signals and the GHG signals are not compatible. Are there any thoughts on how to bridge that gap so you cannot have one or the other but both? Answer: It wasn't part of the project to investigate price signals; however, these issues may be part of the commercial implementation stage as we move from the EPIC demonstration into commercialization. We would examine issues like this in the deployment stage, but individual benefits were examined separately and tallied without considering the interaction of price signals. MBESS are primarily intended for use in emergency situations and not to participate in the markets.

2.2.2. Safety Training Simulators

• Module 1: For safe operation of the network requiring various technologies/applications: Configure existing software to channel real-time data into a common platform for future use by system operators in the real-time environment. Set up and demonstrate an associated training capability for operators.

• Module 2: For Journeymen Lineworkers: Use of virtual reality training to improve the training experience. The abundance of DER in the form of both solar and energy storage is increasing and the related threat of back feed during grid outages is thereby increased. This threat adds to that already posed by inductive coupling with nearby energized circuits. Augmented virtual reality technology would allow personnel to perform the tasks in training and improve their performance in the real world, on potentially energized systems. The chances for a misapplication of these safety-sensitive tasks are reduced. Student learning is enhanced by the VR technology.

2.3. Southern California Edison DAC Demonstration Benefits

2.3.1. Service and Distribution Center of the Future

• DAC ability to replace diesel buses with electric buses on the J or Silver line in the LA Metro territory

• Help LA Metro and other transit agencies through the journey of electrifying their fleets

• Facility in El Monte will be LA Metro's first fleet depot electrification supporting over 200 buses

• Electrifying a fleet of this size takes a significant infrastructure investment to support the charging

• Level of investment and the complexity can be affected by managing the infrastructure and optimize with the fleet operations

• Leveraging other programs and opportunities with EPIC concurrently i.e. Charge Ready where SCE is helping customers in different sectors put in electric vehicle charging infrastructure

• Key benefit stream is reduced diesel emissions on the bus line (see Workshop ppt. slide #23 for the areas impacted) and outage resiliency of bus charging with energy storage

• Goal is to use DER to more cost effectively support electric bus charging services

• In terms of long-term affordability, project is leveraging the same work on microgrids to implement a strategy at the site

• Use cases include: Load Management/Demand Response, Grid Support, Resiliency, Building Electrification, EV Charging Submetering

3. Workshop Question: Are there preferred resources and/or types of demonstrations that would be most beneficial to DACs and under-resourced communities?

Q: Does the CPUC or CEC have or maintain a list of DACs that have expressed interest in participating in demonstrations?

A: SCE has the largest number of disadvantaged communities of the three California utilities. There is a disadvantaged community advisory group that does speak on behalf of disadvantaged communities, but not aware of a specific list. CEC has designated a specific percentage of their budget of EPIC funds for DACs and a smaller percentage for underserved communities, so they are a possibility for more information, and we will follow up as well.

Update: The state maintains an on-line resource for finding DACs at the link below:

https://gis.water.ca.gov/app/dacs/

Participant Comment: Something to think about as we speak of the disadvantaged community topic, I think many of us are aware that there is also in process an infrastructure bill, IIJA. To be more specific and equally as EPIC, the IIJA is looking at how do we also take advantage of this type of funding and help our disadvantage communities? As you know in some cases, we might be able to leverage some of the EPIC funding with the IIJA to do things that sometimes we might not be able to do given the number of resources we get through EPIC. The work we do here for DAC can inform the IIJA.

A: Good input and it connects with another thought; if you do something like that, you go out and reach out to others for match funds and you bring in other partners. That all adds to the timeframe for a project, and if it's a large EPIC project, the process can get very complex in that regard. You would need to really stretch out and have a well-thought-out time schedule and allow for all these steps in the project plan.

One of the examples that has come out of our ideation internally is the idea of electrifying one of the light rail trains down in the San Diego County area and putting some new charging infrastructure at the stops along the way. It's now diesel, so it has all kinds of neat connections like emission reductions and goes through multiple DACs. However, to do something like that would probably consume our entire EPIC-4 budget. But remember, we have the smallest budget, so the general point here is that we can only go so far with the EPIC dollars the IOU's have, and we could be doing a very small number of projects. In the case of SDG&E, it might be as small as one.

4. What can communities do to get involved in demonstrations?

4.1. SCE – Engagement

Communities can follow some of the considerations SCE uses to source demonstration locations and can partner with SCE to identify those considerations.

4.1.1. Technical Considerations

• What problems are we trying to solve in planning or operations and the potential benefits: reliability, resilience, environmental impact or a combination of all

• Site considerations include electrical capacity, access & security, telecommunications possibilities, existing customer assets, i.e., solar, storage, charging infrastructure

4.1.2. Social Considerations

Community characteristics include:

- How can the project help the community and communities like it in the future?
- High fire risk areas and high wind events
- Costs and funding partnership create more opportunity
- Communities with high level of interest

4.2. PG&E – Engagement

Point of this workshop is to generate interest and engagement as we move into EPIC-4. How to partner with the IOUs for projects is the key question. PG&E notified our community-based advisory group and will continue to work with them to engage communities in upcoming workshops for comments. As we get into projects within the EPIC 4 cycle, which runs 2020 through 2025 of initiating projects, that's certainly one thing that we always look for, is there some intersection? Is there some way that this project could be cited in a disadvantaged community that provides benefits? Blue Lake Rancheria had reached out to PG&E which is always great when the communities can come to us. We're looking to do more of our own outreach as well and are hoping for collaboration on project ideas.

4.3. SDG&E – Engagement

• Current activity in the schedule is for ideation and trying to get the applications into the Commission, but then there's another period after the applications approved where we're implementing projects and that's where we would reach out. As we learn which projects, we are actually doing at SDG&E, we would reach out to specific DAC or community organizations to see if there's a project that is uniquely suited to them. We don't want to spend a lot of time and effort conjecturing what projects we would do now, because that gets decided later. We invite input at any time. Reach out to any of the three utilities or the CEC with any ideas you want to present using the contacts provided (see Workshop ppt. slide #28 or on the front of this document).

• Another way to stay aware of what is concluding in EPIC-3 or forward looking to EPIC-4, is to monitor the three utilities' public websites and/or the CPUC has established a public database. https://database.epicpartnership.org. The database provides a broad view of everything that has happened under EPIC across all four administrators, including DAC projects which may help formulate new ideas.

• Finally, the projects could run longer than 2025. The year 2025 is the end of the period by which the money must be committed, but execution of the work can continue beyond 2025, once the project funding is committed.

5. Closing

• No further questions were raised therefore, follow up will occur via email between participants and the utilities. A summary will be provided to provide additional fuel for thought for new questions.

• Thanks to all participants, presenters and organizers!

<u>Joint Utilities EPIC Public Workshop, June 30, 2022</u>

1. **Theme: Create a More Flexible Grid to Maintain Reliability as California Transitions to 100% Clean Energy**

    a. **Topic Discussion – Ultra-Low Latency Communications**

Oral Comments

<u>Brian Deaver, Sr Technical Executive, EPRI</u>

What use cases were identified that would be the first ones you'd want to evaluate with this kind of communications technology?

    b. **Topic Discussion – Inertia Substitution**

Oral Comments

Brian Deaver

Any early effects of this nature, more penetration of DER the more widespread effects. Has anyone experienced that?

Patrick Saxton

Are the IOUs active participants in the Universal Interoperability for Grid-forming Inverters (UNIFI) Consortium?

Panel Discussion

IOUS are all actively involved; we will have a candidate topic for EPIC 4 Investment Cycle

Haresh Kamath, EPRI

Will this address the degree to which inertia can be addressed with grid-forming inverters?

c. **Topic Discussion – Adaptive Communication and Control Infrastructure for Advanced Distribution Systems**

Brian Deaver

Is the thought process here, not just having DER monitored and tracked but also bringing it into utility control algorithms in the ADMS?

Haresh Kamath, EPRI

Will this topic include work towards standardization of open-standard communications and control protocols for DER as well as existing utility assets?

d. **Remote Grid and Microgrid Enablement**

Achintya Madduri, CPUC

Has any of the micro grid research looked at the capabilities of smart inverter functionality beyond volt/var? E.g., freq/watt or volt/watt? These other functions are intended to provide some form of virtual inertia.

Haresh Kamath

Might the research in the Remote Grid and Microgrid topic address the relatively high cost of microgrid deployment, beyond standardization of designs

e. **Topic Area Discussion - Individual Customer Resiliency**

Haresh Kamath

Might the Individual Customer Resiliency topic include research into utility programs for front-of-the-meter assets?

f. Topic Area Discussion – Long-Duration and Alternative Advanced Energy Storage Systems

Haresh Kamath

How much work will be done in determining exactly how much long-duration storage is necessary and what the duration should be? Will there be work into assessing how long-duration needs (especially for contingencies) might be satisfied with a portfolio of short-duration assets?

g. Topic Area Discussion - Mobile Microgrids

Haresh Kamath

When it's said we need long-duration energy storage, I believe the real meaning is we want long-duration energy storage at a low $/kWh price.... if we absolutely had to have long-duration storage at any price, it would be possible to run short-duration storage at longer durations, though such an approach would be expensive. Is there a price target for long-duration storage?

Jeff Malin

What is the current schedule or timing for any LDAAESS analysis reports?

Judith Ikle

Mobile microgrids have so many interesting use cases. How are you able to design to serve disadvantaged or underserved communities? Please include wide variety of users in project design need finding.

Bridget Horan

The production and use of customer sided DERs is inherently a human enterprise. Applying social and behavioral science research to energy policymaking is therefore vital for creating a more efficient and comprehensive solution to our energy needs. In order to continue to provide power to the people while limiting environmental harm, what factor of the human element is understood and incorporated into the DER strategy as discussed?

Patrick Saxton

Harmonics on the secondary side of transformer, correct? What utility assets are potentially damaged?

2. Theme: Increase the Value Proposition of Distributed Energy Resources to Customers and the Grid

a. Topic Area Discussion - V2G Technology Development and Interoperability

Liang Min

Do you also look into the ways for EVs to participate in CAISO market?

Jordan Smith

Here is a link to one of the several V2G CAISO market pilot reports.
https://www.energy.ca.gov/sites/default/files/2021-06/CEC-500-2018-025.pdf

b. Topic Area Discussion – Interconnection Enablement

Bridget Horan

The production and use of customer sided DERs is inherently a human enterprise. Applying social and behavioral science research to energy policymaking is therefore vital for creating a more efficient and comprehensive solution to our energy needs. In order to continue to provide power to the people while limiting environmental harm, what factor of the human element is understood and incorporated into the DER strategy as discussed?

Liang Min

Besides solar, will you also consider storage?

3. Theme: Inform California's Transition to a Zero Carbon Energy System

a. Topic Area Discussion - Long Term Grid Planning

Liang Min

Great project, especially T&D coupling and long-term planning.

CAISO released the first-ever 20-yr transmission planning early this year. How do you coordinate this project with CPUC LTPP & CAISO TPP?

Will you look into the sector coupling issues, such as power to hydrogen, power to heat, power to liquids, storage and EV?

b. Topic Area Discussion – End-to-End Advanced Simulations and Analytics

Jonathan Mele

Can anyone share thoughts on distribution system analysis, specifically what are main gaps with popular tools like CYME and Synergi? Or if anyone's evaluating/piloting other tools?

Mehdi Ganji

For those utilities such as PG&E and SCE who operates the non-electric infrastructure have you looked at interdependencies between non-electric and electric infra.?

a. Topic Area Discussion – Light Rail Electrification

Liang Min

Industrial sector accounts about >20% of the total CA GHG emission… I would encourage IOUs to explore the industrial sector electrification/decarbonization? such as electrifying the processing heat.

Judith Ikle

Transit is important to address. Please expand discussion we just had re barriers to deployment of light rail in SD. Also helps with access to clean transportation.

4. Theme: Advance Toward a Climate Resilient Electric System

Christopher Parkes

Promising undergrounding technologies?

Joint Utilities EPIC DAC Workshop, August 25, 2002

1. Open Discussion – Requesting Comments from Community Representatives

Written Comments

Anna Solorio, Non-Profit Community Housing Opportunities Corporation
Have you done an analysis of number of LI (Low Income) owners of EV in DACs for the buyback battery idea, EV ownership tends to cluster in high income brackets.

Organizers' Discussion
The EPIC team has not done this yet, but this is a topic we could work with our internal equity team on to understand those analytics and the potential opportunity there. A fair point for the transportation electrification topic area, we need to be mindful what the adoption, and the ability to adopt is, in the DACs as a starting point.

This is an example for EPIC 4 to better coordinate and leverage customer programs to bring what is done with EPIC out in the field to be more collated and coincident with the customer service organizations in order to help customers with adoption. This is an opportunity in the EV space but also in different types of programs as well.

Oral Comments

Rich Tree, Representing City of Oroville
Following up on the re-purposing of EV batteries, we have a fleet of heavy-duty transit buses that are battery powered and in secondary life. It's exciting to see the advancement and wide range of topics discussed for EPIC 4. One area for future consideration that is maybe an expansion of what's already been discussed today is the opportunity for battery swapping as it has a lot of purposes within it. A large facility can be charging these batteries at the most optimal time and swap them quickly in vehicles but also expand on that as potential energy storage in the meantime as a dual focus.

We have partnered with out utility provider who has helped us a lot with their programs to transition our fleet. Currently we've been successful with two charge-ready transportation projects. The infrastructure is in place but maybe there is an opportunity to revisit the agreement to expand on the infrastructure to include a microgrid to create resiliency and build on this investment, and/or add energy storage to that project as well.

Organizers' Discussion

For consideration on the utility side, is the value of taking a demonstration site and building on that to leverage what has already been done to serve as a "living laboratory." This must be weighed against ensuring that we're also working with other communities and allowing them the opportunities to benefit from the limited resources we have. A challenge is how to make that trade off to build on things we've done but also make sure we're being inclusive and giving opportunities to other communities.

PG&E is broadly interested in exploring alternative charging technologies and are considering wireless magnetic charging and the battery swapping concept as mentioned. We are still defining topics but there are a range of possibilities in this area we are exploring to demonstrate in the field.

Anna Solorio

In relation to the Inflation Reduction Act that just passed, there may be significant tax credits for EVs. This might be an opportunity especially in DACs. Suggesting you partner with community-based organizations in DACs to help further identify products that might be useful/valuable to support equity in these communities.

Organizers' Discussion

At SCE we are proactively thinking about how to best leverage the potential Federal funding opportunities that are coming. How to help DACs are already a factor in consideration but we will further double check and validate that we are thinking about what areas, there is potential to move the needle in EV adoption in DACs.

Moving from topics to a project after the initiatives are settled; light rail electrification for example, could very easily consume all of SDG&E's budget so we have to be mindful of total cost, go through the feasibility phase and try to engage community support in helping to raise co-funding. We are supportive of the concept of community engagement and partnering and it may be necessary in the projects SDG&E ends up doing.

2. **Open Discussion – Do you see opportunities in the highlighted EPIC 4 topics? Are there technology innovation areas of relevance/importance to DACs not covered in our EPIC 4 topics?**

Anna Solorio

In terms of working in DACs and being successful in DACs it's really important to have partners that know and work in the area. I would add to your thinking to work on developing some partners or reaching out to CBOs. Other efforts have put together Low-Income Advisory Boards in DACs to help them be successful. I wanted to offer that as an additional idea as you roll out these projects.

Organizer Discussion

One of the avenues for PG&E outreach was going to the members of the relatively new PG&E Community Advisory Council. Is this a good place to start or do you have any other ideas for the PG&E service area?

Anna Solorio

Start with the PG&E Council and then TECH Clean California has a low-income ambassador board providing advice on how to increase the adoption of heat pump water heaters in DACs and low-income communities. They are another good resource and from there you could find additional resources for feedback, ideas and how to increase your success in those areas.

Joint Utilities Public Workshop, August 29, 2022

1. Open Discussion on Strategic Objective: Create a More Nimble Grid to Maintain Reliability as California Transitions to 100% Clean Energy

Oral Comments

Ben Wender, CEC

How much do the utilities envision doing laboratory or specific controlled testing versus demonstrations on live systems and getting technologies out in the field?

Organizers' Discussion

SCE: One thing we can comment on is the factors and tradeoffs which include: doing things in the field is very expensive and time consuming relative to the lab so one of the considerations is, when emphasizing lab work, we can touch more areas and evaluate more potential solutions. On the other hand, there is no substitute for real world experience to get a sense if something is going to integrate well or not. The best portfolio of projects for us is a mix of the two, not all one or the other. We are still trying to figure out what the optimum is but maybe a smaller number of field demonstrations that present the opportunity to incorporate multiple subject areas provides certain economies of scale. Another dimension to that question is what efficiencies can be achieved by grouping certain projects and activities as well.

SDG&E: To add a few points, in EPIC 1, we had largely a laboratory-based program. Our entire portfolio in EPIC 1 was an initiative in advanced distribution automation that touched on several areas including, visualization and situational awareness, system architecture, grid support functions of DER and others. We tried to do a lab phase that would ultimately lead to a field phase, but we were limited because of cost. So, in some cases in EPIC 1, we stopped at the laboratory phase. As we moved to EPIC 2 and 3, we intentionally tried to get more into field demos with some success and got into programs such as UAS and advanced SCADA augmentation safety training simulators. These projects targeted a field phase right out of the gate or after an initial lab phase such as in the mobile battery project. We had an initial lab phase but got the battery out in the field as quickly as we could. It will probably be a mix going forward, but we prefer to go to the field phase eventually. When we make project choices, we will limit the number so that we can get into the field phases and limit the amount of work in the lab. We seem to have had enough success in moving toward field phases with a smaller number of projects, so we'll continue that path.

SCE: When we come across something that is relatively new to us and will clearly add value and is feasible, sometimes we find that it can be incorporated into capital investment. The limitations we have with EPIC funding doesn't necessarily mean we are precluded from advancements overall. Part of the process is also evaluating how mature is the new opportunity and if it's something that should go in EPIC or go to capital investment.

SDG&E: We do the same thing with our small EPIC budget; we look for opportunities to go right to a capital project. An example is the commercial deployment of phasor measurement units (synchrophasors). We had used them at transmission and went right to a commercial program to deploy them at the distribution level without doing R&D first.

PG&E: In working with the DACAG, DACS, with CPUC and CEC and also individually as IOUs; we look for field demonstrations within DACs. Looking at the EPIC 3 portfolio we have several field demonstrations that are examples of how there is no substitute for field testing. Sometimes there's no opportunity for testing in a laboratory. A field demonstration can get you closer to the path to production and with confidence. For example, in the data analytics projects we've been doing, we are taking data from the field and developing algorithms and techniques, and even though it is taking place in a laboratory, we can rapidly go to production with these analytics systems during the projects.

SCE: Another important opportunity is also leveraging CEC programs which may create opportunities for IOUs in that territory to collocate some of their work. We should continue to proactively pursue as those opportunities arise.

SDG&E: Another question that comes up is, "what is the field?" An example is a project in EPIC 3 on augmentation to our advanced distribution management system which is a control system in our infrastructure. We piloted some new features for the ADMS, which we tried in the EPIC project to ensure it worked, before we permanently adopted the features in the ADMS. The EPIC work established that the value proposition was sufficient for commercial adoption.

SCE: Labs can mean different things too. We have a lab that's located at a substation that allows us to do things in an environment that looks and feels like the field. We call it a lab because it's a controlled environment and we can test things there without affecting any customers.

SDG&E: We have our Borrego Springs Microgrid that's been evolving over time. We consider it a field laboratory even though it is a real working microgrid. We've been deploying and testing new concepts there regularly.

Qing Tian, CEC

Do you have the budgeted amount for each of the topics presented? If you don't have it, are you expecting to include it in your final submission to CPUC? We have some areas that have some potential overlap, and it would be helpful to know what is budgeted for the research topic areas to coordinate for future solicitations.

Organizers' Discussion

SCE: What we will file will allocate budget across initiatives. We are still working through how we want to allocate.

SDG&E: The same is true for SDG&E. We aren't choosing projects in the investment plan; we are only giving candidate topics within an initiative. There will be budget allocations made to the initiatives. Until you've chosen the projects, once the investment plan is approved by CPUC, you can't really start a detailed estimate of the requirements of an individual project. So, we'll be budgeting by initiative.

Ben Wender, CEC

In terms of priorities for the IOUs and thinking about the process by which the IOUs and CEC can coordinate, are there specific topic areas that are priorities? Long duration storage might be one that can be prioritized to work closely with CEC, thinking about how we can make our investments complementary and synergistic. Are there other topic areas you want to flag/start thinking about, and do you have thoughts so far on the mechanism and process on how that coordination would happen over the EPIC 4 duration?

Organizers' Discussion

PG&E: we are hyper focused on the Oct. 1 filing date so after that we want to make sure that as the CPUC evaluates the plans, we coordinate with CEC a lot. Starting in October we want to look at the full process. I think this was your idea, to get a template for the partnership so that we can make this a simpler and more efficient process for EPIC 4. The fourth quarter is the time we want to dig into that. As far as other topics, the biggest opportunities for alignment with CEC are long duration energy storage and micro grid enabled topics, both areas where we've already had a lot of conversations with the CEC.

I think it's about coming up with the right model or blueprint for how to do joint or partner projects with the CEC in these areas going forward.

SDG&E: Long duration storage is a good example of where collaboration is not only desirable but also necessary. Batteries are just an interim stop gap solution. For the amount of long-term storage that is going to be needed in the mix of resources, we've got to get beyond batteries. Options like thermal storage can be coupled with concentrating solar power, storing thermal energy from the concentrating solar system when it's not needed and using it when it is needed will extend the daily cycle potential of solar energy. Other examples are compressed air energy storage, liquid air energy storage, and further down the road, superconducting magnetic energy storage (SMES). All these things are going to be expensive to pursue in EPIC, certainly beyond the SDG&E budget limitation. However, we are seeking additional money in our GRC for long duration energy storage. Even with that, it's much bigger than SDG&E can do alone; so all the Administrators need to collaborate in this area. Superconducting magnetic energy storage requires development, and only CEC is allowed to do the development phase in EPIC. The utility could perhaps get involved in the storage aspect, but we can't get involved in the generation work with EPIC funds. Those are some of the constraints that push toward collaboration with CEC and/or industrial partners.

SCE: We are pleased about the focus on long duration storage in terms of an area for collaboration. Amongst the four administrators we need to work together so we can try more things and not duplicate efforts in terms of trying new technologies. Another thought is to how to identify further in advance, where and when the CEC may be supporting projects so we can figure out collectively how to fund and support what the utility can do to support a DER type project to get more value for the customer and help acquire a good location and partner in working through the utility side of DER integration.

<u>Divya Softa, Peak Power Inc.</u>

A question for Southern California Edison, wondering if you could expand on the information related to the seamless grid flexibility topic, specifically, what are some of the pain points you've been able to flag?

<u>Organizers' Discussion</u>

SCE: Between the complexities of DERs, new EV charging load, resiliency considerations including but not limited to, wildfire PSPS situations, there is more changing more quickly on the grid on a regular basis. Having both the analytical tools and the control and communication capabilities to more quickly make adjustments on how the distribution system is configured will help us more cost effectively and quickly respond. For example, when changes occur, customers that are getting power from a certain distribution circuit becomes heavily loaded. Perhaps there's a nearby circuit where changes can be made in some of the switching configurations such that we can have the less loaded circuit support the affected customers. I think with additional technical capabilities, we can resolve issues more quickly.

2. Open Discussion Strategic Objective: Increase the Value of Proposition of Distributed Energy Resources to Customers and the Grid

Written Comments

<u>Patrick Saxton, CPUC</u>

For SCE on NEM optimization: How does this complement Smart Inverter functionality? Is it the control system to make better use of that existing functionality?

<u>Organizers' Discussion</u>

SCE: There are two elements from the utility perspective, one is the communication and ensuring all is working properly and we have established the appropriate protocols. There is still work to do implementing the protocols and making sure we're able to do so consistently and reliably. Then there is the control. The CEC and IOUs have already done great work in starting to think through when we have multiple DERs. For example, we just completed a project funded by the DOE and also included SCE and CEC EPIC funding called the electric access system enhancement project. We did work both in the lab and in the field demonstrating algorithms that will help us optimize how multiple DERs on a distribution area fed by one substation and the distribution system could operate together to manage loading on that system. That report will be publicly available soon. We've learned a lot, but we've also identified a lot of questions and things that we need to continue to explore.

Oral Comments

Robin Goodhand, CEC

You described a scenario where a group of entrepreneurs help in developing sensors and challenges with communication protocols. What kinds of services do you have to help entrepreneurs test and validate and prove out performance of individual sensors or inverter or switchgear or other types of DER assets? Is there a central testing facility like a business service offering where engineers can work with the utility?

Organizer Discussion

PG&E: Yes, PG&E does have the ATS which is a laboratory out in San Ramon that is at the end of a feeder, so it's connected to the grid as well and has a large set of laboratories with a lot of demonstrations done of different types, including sensors. In various systems we have operational and test networks that don't have to be as rigorous as they're not connected to any of the operational technology. Where the issues come in is when vendors need real data or real interaction with the operational device technology. It's getting those sensors across, not into a test system, but interacting with live data so there is a real-world test. This gets more difficult when it comes to a security and integrity point of view. Exceptional processes inherent to EPIC, have more friction and so we are looking for ways to reduce that friction in our innovation and emerging technology projects. We are exploring ways to have a common platform for integration, so we don't have to go through so many of the hardware and software issues to get a sensor connected. We can bring it into our big data foundry.

Robin Goodhand, CEC

From my experience overseas, there comes a point where utilities must be able to perform testing. In Australia for example, there was concern about the number of solar inverters connected to the network and they wanted to test out what would happen if 100 inverters were connected together and test it in a controlled environment. They did it in an off-grid testing facility where the utilities could "abuse" systems to see what would happen in those scenarios. Does anything exist like that here?

Organizers' Discussion

PG&E: Yes, that's the Applied Technology Center out in San Ramon and is available to tour if you want to see the facility. We have a large set of laboratories and equipment for some of the EPIC 3 projects that are run out of ATS directly where we test the microgrid. Other testing such as sensors and drones are run out of ATS.

Robin Goodhand, CEC

Is there a formalized certification that comes out of that process, such as ATS-approved or certified or conforms to a certain standard?

Organizers' Discussion

PG&E: We inform the official standards body working with IEEE, ISO, ANSI and other standards groups to modify or often we're leading those standards efforts. Talking about interoperability, PG&E is not a third-party market based or an industry trade group organization, but we can provide our services. We've discussed this as part of the setting up of laboratories and that we have unique skills and facilities for interoperability testing. An interoperability certification program might be able to leverage our labs to get to the goal faster and less expensively.

SCE: We have labs as well for different purposes and I believe SDG&E does as well. We also have world class universities and national labs in the state with capabilities as well. I'm not aware of one single place where you can locate those capabilities across the state. Something interesting to work on possibly is to look at the capabilities in the state in terms of a facility because we have a lot of great options. Another thing to mention is as the utility, we're not the certifying body. We aren't going to test the product and say "Ok this product is safe for anyone" or that it meets a certain standard. That is not our role, but we do participate in the standards bodies that help establish industry wide standards that we need and adopt. That way we're adhering to industry standards and the manufacturers and technology developers aren't' having to develop a utility specific product but one that meets the right standards that in theory all of the IOUs can adopt.

SDG&E: SDG&E has multiple labs, the principal lab that might be involved in trying out standards is the one in Escondido called the Integrated Test Facility. We are adding to that facility at this time for more capability around protection and control related standards. We have in the past tried out features of the IEC 61850 communication standards. Examples of features that were investigated are peer-to-peer communications and goose messaging. There is a larger point too and that is adoption. Once the standard is available, does the utility want to adopt it or not? That is where you need to try it out in order to make that decision. Back to the point about sensors and how do we easily integrate? Standards can make a plug-and-play process out of assimilation of these sensors or any other new technologies. That is where you need a universal standards platform. IEC 61850 is probably the best in class in that regard and it has had widespread adoption in Europe and South America where there was more of a greenfield situation. North America has a legacy standard called DNP3 which has a big investment and so to move from that legacy architecture to the 61850 is a big deal. It will probably happen gradually over time. I believe SCE was migrating its substations to 61850, but I don't' know if that process has continued or not. In order to make sensors or other devices plug and play, you need a universal standards family that has staying power. The last point is a DER (among other functions already discussed) has the capability to act just as a sensor whether it's doing the other functions or not. This is where again you take a standard like 61850, and it's broken down into what are called logical nodes. There's a group of logical nodes in the DER standard that just deals with its sensor capability. That's why you move to these standardized platforms, to get everybody doing it the same way, so that when you want to buy a vendor's product, they don't have their own confidential (non-standard) protocol that you have to address with extensive custom design work.

Loon Yee, CEC

I want to find out among the three IOUs, do you actually have any communication to say at what stage you are adopting certain standards? When in the lab to verify that if certain subsystem or components actually meet certain requirements, do you share the information among yourselves? When a supplier or device manufacturer provides these devices off the shelf in the market, how are you going to ensure that those devices meet the requirements of the standards? Do you do this in the lab? I

Organizers' Discussion

SCE: There are industry standards and at SCE we also have our own design standards. When we're building for example, a substation, here are the requirements to implement it. I'm not sure there's a hard rule that says at a certain point of time that a product will get incorporated into an SCE standard and is probably more needs based. It is more the case of what problem is that new opportunity solving and how important is it to solve that relative to all the other things we are trying to do. One of the challenges is prioritization but we do have a well-established internal process where we adopt new internal design standards. For example, we may do something under EPIC, where we test something in a laboratory environment or out in the field showing that a new product, or combination of products is more often the case, is effective. We're confident that it's safe and reliable and that's where the industry standard/product certifications are helpful in enforcing or strengthening that decision and then so we can start our internal process to formally adopt. For example, prior work we've done in EPIC has gone into our distribution design standards. We've updated our distribution design standard in the area of automation where equipment and automation schemes that we've tested in EPIC ultimately became incorporated into our distribution design standards and there are specific examples in the substation area as well.

PG&E: I just want to add on that there's these certifications from interoperability organizations but just because a device or system has this seal of approval doesn't mean that it's perfect. These certification programs are limited themselves, in terms of funding or complexity. They may be testing basic things like conforming to protocol types of things but the more complex types of operations and interactions you get in a real grid environment have not really been fully tested because it's so difficult to do that. It's necessary and a very good thing but there must be more complex scenarios in the ways we're going to be using these things in these complex environments so it's a layering of things.

Loon Yee, CEC

I agree that the standard is meeting the minimum requirement. When you put in that device that's been certified into your application, it may be more complicated. The certification is good for certain aspect of the design but not comprehensively. I agree on that one because based on my experience, certification is a certain aspect of insurance or assurance, but it doesn't mean everything.

Organizers' Discussion

PG&E: I'll say we're not downplaying the importance of these. We prefer standards, we develop standards, and we push standards. They are necessary, and we lean towards them, want to adopt them and push everybody to adopt them. Then there comes the interoperability and testing so it is an evolving thing.

SCE: That's where I see the most value, is the integration and what we learn working through the integration. The industry standards often are a helpful precursor to working through the integration, but we learn a lot and that helps pave the way to actual adoption.

SDG&E: The other piece of the puzzle is new features, and I agree with what Josh and Damian are saying about how utilities are not going to be a certification organization on behalf of the whole industry. There will be new features emerging. Take inverters for example. New features are going to emerge, whether it's inverters or any other device that's being integrated into the utility system. The standards need to evolve over time and be recertified as new features are added into the standards. That has always been the process with IEEE standards and IEC standards, and it will continue.

Loon Yee, CEC

If you have time, I want to come back to the inertia substitution. We really want to find out what kind of projects or work that you plan to do behind that inertia substitution topic. Do you plan to use the battery? I think that that's the one big storage project in Australia that they call digital inertia. The IBR is going to rely heavily on the inverter in the future so we are going to move some of the rotation mechanisms (generators) offline so how will you go about that? I think that will be a big issue from a reliably standpoint.

Organizers' Discussion

SCE: I think batteries are going to be a critical part of that, but they are also not the only tool. There are other types of equipment that we can install and various types of reactors that can also help. So, I think that the work that I envision happening here, still talking about the topic level, should be looking at the simulating in the lab, power systems that are operating under these conditions with batteries and the other equipment that we have in the grid along with the loads to see what combinations and configurations that best support stability under those various conditions. I think we can build on some work that we're already doing that is outside of EPIC but related to work done where we're modeling portions of the bulk power system and simulating how we could use inverter-based resources to black start a portion of the grid. I can see an expansion of this to include how to maintain stability under normal conditions, and we should be thinking about all the resources we can make available to support that. Batteries will be critical but not the only tool either.

Loon Yee, CEC

Is storage the main tool you use, or do you have another means? We talk about superconductor magnetic storage with a very fast response time as maybe one option, but do you have anything specific?

Organizers' Discussion

SCE: I have to go back and look at notes and/or ask for help because you're getting into areas that are beyond me. Maybe we could have some follow up and get into the details and get the right people in the call.

Loon Yee, CEC

A last question is about the edge computing, the edge control. How edge is "edge"? Do you push down to the distribution level, transmission level, substation, receiving station? What level do you consider as edge?

Organizers' Discussion

SCE: I think that's anything within the boundaries of our footprint. So, meters are on the edge. Microgrid controllers are on the edge as are service transformers. Maybe not on the edge but close because there's not a whole lot between them and our customers. So those are some examples, also electric vehicles and support equipment are on the edge. One can envision having some control capability that was operating locally. The benefits of that would include reducing the amount of bandwidth that's needed for communication between the field and back office. Also included are the resiliency benefits and having some local autonomous operation capability.

Loon Yee, CEC

Do you see a demarcation between the utility, OSS and also the microgrid that will define the edge? If you want to come to my grid or territory and we have edge devices, you can call it the entry to migrate?

Organizers' Discussion

SCE: What we're seeing now, and I think will continue to be the case is that there isn't one microgrid controller: ting energy onto that microgrid. That's where those areas and responsibilities overlap.

Loon Yee, CEC

When you mentioned reduced bandwidth because of latency, etc. Do you use commercially available cellular services for your communications, or do you have to rely on some of the satellite communication for your edge?

Organizers' Discussion

SCE: We have multiple modes of communication today. There are wires, fiber optics, cellular and satellite. There isn't just one mode of communication that takes care of everything.

Dr. Mehdi Ganji, CEC

Have you thought about a utility-owned and operated communication and control platform that is going to be used by a DER owner or even in some cases the operator? We know that the biggest barriers toward the integration of the DER and microgrid is the lack of visibility that utilities have on behind the meter resources and also lack of control as well. Through the utility owned and operated communication and control solution, a lot of issues related to the integration of DERs would be addressed. However, it requires a lot of data validation. Have you included this type of project in your EPIC portfolio?

Organizers' Discussion

PGE: Yes, we didn't get down to the details as in the sensing communication topic, but we would like to investigate using some of the newer communication platforms that would solve several of the problems that we have today. We would like to see a more interconnected, singular type of security system that is easier to connect into with the ability to support fixed, mobile and third-party devices. We are looking to find a path to solve our communication problem as it's our problem, and it's also California's problem and our customers' problem. But there's no off the shelf solution.

SCE: I don't know if we have a project dedicated to exploring this issue, but we are touching it in various projects and especially those that involve integration of utilizing third party DER and how to operate a microgrid, in particular. The challenge is how to build these bridges so we can do the things we want to do without taking undue cyber security risk. We have some projects in EPIC 3 that are specifically cyber security projects. Even those that aren't specifically cyber security projects have an element of cyber security because we're integrating equipment communication which impacts cyber security.

SDG&E: The last topic we presented around advanced communication and control is broad enough that it is intended to include some migration to a standardized platform that would enable the easy plug-and-play assimilation. For topics that might emerge, the bandwidth is in that topic area to include the trials and validation of standardized solutions for plug-and-play processes. And the point raised earlier about what is the grid edge is a good point and is dependent on circumstances. A microgrid for example, can be entirely off the edge in customer space, or entirely in utility space, or a hybridization. The original ideas around microgrids before they were so named, was a reconfiguring option to be able to island a part of the distribution system, if it had enough distributed resources in it to do so in an emergency. You could reconfigure by islanding that part and keeping it up when there's a larger system contingency. As microgrids evolved, it has become more about customer owned assets, but not to the exclusion of the possibility of utility owned microgrids. Either way, you want standardized interfaces available in those various resources that are in the microgrid.

3. Inform California’s Transition to a Zero-Carbon Energy System that is Climate-Resilient and Meets Environmental Goals

Oral Comments

Ben Wender, CEC

Could you talk about the process by which you go from these higher-level concepts to more specific technologies and project plans? Are there opportunities to weigh in during that process? How does that happen?

Organizers’ Discussion

PG&E: There will be a level of detail in the investment plan that is below what’s been presented here as it’s just not possible to go into that level of detail here. We are following the CEC’s format for the investment plan, and we will be adding some additional details at a deeper level. Regarding process, there was a lot of collaboration between the CEC and the IOUs in previous EPIC cycles. But because the filing is at the initiative level and not individual projects, there will have to be a much deeper level of collaboration between the IOUs and the CEC. I envision a lot of communication as we set up these individual projects. It won’t be as formalized in the EPIC Investment Plans so we will have to make that process work so that we have the most effective projects.

SDG&E: That is true for SDG&E as well. The topics themselves are fluid. They are candidate topics and, if we have placed funding in a given initiative, we will not limit ourselves to one of the topics that we identified as a candidate now, as long as a newly emerging idea has high priority and maps to that initiative. Even though there are no topic areas listed for SDG&E under this third initiative area (zero carbon and climate), we do have a grid hardening program in the company. We could pick up urgent grid hardening or other resiliency demonstration work (if necessary) in the realm of another initiative—for example, in the previously discussed topics on advanced communication control and visualization type activities--rather than create another activity topic in this zero-carbon initiative. There is overlap between the scope of the initiatives. If we take our limited EPIC budget (about 14 million for the whole EPIC 4 cycle), we can’t spread it out too broadly, so we’ve tried to narrow down to the initiatives with the most importance in terms of need for ourselves, the industry, and our customers. We will book our funds by initiative, and then, not only the current candidate topics but also the possibility of funding other topics that may arise and map to those initiatives will be considered. The next step after CPUC approval of our investment plan will be to go to our management with a prioritized list of which topics within these initiatives we recommend pursuing as projects, and we will seek their approval. We won’t be able to do everything obviously, but we want to be coordinated with the other utilities, the CEC and what is going on broadly in the industry.

SCE: We will take what we file and then we’ll go through some internal brainstorming type of sessions for some project concepts. Part of the requirement by the CPUC of this process is that we hold public comment opportunity for a specific project so there will be opportunity for public comment before we launch these projects. Another opportunity is at www.sceideas.com where anyone can make a submittal to bring things to our attention to work on. This window is always open regardless of where we are in the EPIC cycle.

Ramandeep Bagri, CPUC

I would like to have more elaboration on the zero-carbon energy topic where you mentioned the pinpointing of the fault location. What is a limitation of the current technology that you use for the fault location and when it comes to pinpointing the fault location, why can’t we extend that technology for that purpose?

Organizers' Discussion

PG&E: We are putting technology out today like one that uses RF sensors to find grid faults. It's a matter of speed and accuracy. Very little of our system is instrumented down to this level that we could process and be able to find the faults more specifically. We want to reuse sensors out on the grid to fuse them together and infer where the fault is. Any one sensor might not be able to provide a precise location but through intelligence across many data sources, the fault may be located. It's a matter of narrowing it down and since it isn't cost effective to put sensors everywhere , the question is how to use lots of different information plus cost effectively use sensors in some locations to gain precise fault location and what the fault might be. An example is line closures may be communicating but we're not necessarily using those data streams and correlating them with other sets of data. That is what does not exist today.

SCE: Through combinations of switching actions, we can determine where the problem is between two switches. When we start getting more sophisticated and for example, measuring waveforms and collecting data extremely fast, that helps us see the shape of the AC power. If we have multiple views we can start measuring distortions at different places such that through analytics, you can calculate where the problem is. It's a relatively new area. Through the combination of the ability to collect more data and process that data more quickly, data can be interpreted in such a way that the location of a problem can be pinpointed.

SDG&E: A project in the EPIC 3 cycle called Focused Patrol was an initial effort to take data from multiple steams to more rapidly locate faults. A vendor created a software platform to our spec. It was tested on a trial basis and found to be useful and was added as a module to our distribution management system. There is still more we could be doing in this area to capture other data streams, and the decision on whether we do this in our EPIC 4 cycle comes down to the question of priority, given our small EPIC budget, versus other options on the table.

PG&E: One of the things we're looking at is timing through fiber optic cable where you can understand disturbances on collocated, let's say conductors, to that fiber optic cabling and how it affects the signals going through. Those can be analyzed at very high speed to provide information about the conductors. There's also tapes that both can be applied that are sensors along the asset. It is looking at a variety of faults after they've happened but also how to be smarter about trying to detect when things are about to happen and pinpoint it.

Written Comments

Angela Gould, CEC

Do you have specific technologies in mind for grid hardening and remediation?

Organizers' Discussion

SCE: I would have to consult with some colleagues to answer that comprehensively but in the area of undergrounding, one of the most expensive parts is the drilling, digging and boring of the pathways for the underground conduits and lines. There is a need for development and technology that can do that more efficiently and quickly than in the past. It seems there is real potential to have significant cost savings in these areas where there is undergrounding. This is the first thing that comes to mind. I know there are others, but I'd have to get back to you on other examples.

Appendix D

Energy Efficiency and Demand Response Emerging Technology Programs

SCE Energy Efficiency Projects 2018-2022

Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET22SWE0023	ET22SW#0023 - Occupancy-based Thermostats for Commercial Offices	Active	2022	The persistence of Covid-19 and remote work is driving new patterns of variable and unpredictable occupancy in commercial offices, where work flexibility is the new norm and employees may go to the office irregularly or infrequently. In many instances, this may become the new norm. As a result, programmable thermostats and HVAC schedules tuned to regular, consistent occupancy may not necessarily be able to follow these new workplace patterns. The proposed project will assess the use of occupancy sensors in HVAC systems comprising single HVAC unit serving multiple building zones. By installing wireless connected occupancy sensors in each served space of a single system, the sensors can communicate with the system thermostat to shut off the system when all served spaces are unoccupied. For example, this could reduce energy consumption on days when teams are working from home, during lunchtime hours, or Fridays when many businesses offer modified work hours as an employee benefit. The technology can be used in both new and existing construction. For existing construction, occupancy-based thermostat will replace or be added onto existing thermostat that controls the single-zone HVAC unit. The thermostat can work with any type of single-zone HVAC units, which are typically constant speed units. The proposed project will measure the impacts of this technology in two California office building host sites. In each building, half of the HVAC units studied will have occupancy-based thermostats installed as the treatment group while the other half will serve as the control group without occupancy sensor feedback. In addition to overall energy savings potential, the study will evaluate potential energy impacts during the summer 4-7 pm period which is being targeted for peak load reduction programs statewide. The study will also perform secondary market research on workplace occupancy patterns, determine the total available commercial market for this technology, identify the landscape of compatible enabling occupancy sensor technologies, perform field energy impact measurements, and survey host site employees to assess occupant comfort	2022	2022
ET22SWE0022	ET22SWE0022 - Residential Housing Characteristics Study	Active	2022	This California Low-Income Residential Housing Characteristics Study project proposes to address the lack of complete data on housing structures in disadvantaged communities (DAC) and Hard-to-Reach (HTR) single family residential housing. While high level data such as number of homes in DACs and other key demographic and market information (housing age, access to broadband, etc.) can be pulled from census and other research, data on the baseline physical conditions of DAC and HTR homes is lacking (i.e., structural integrity, electrical panel and wire capacity, and code adherence). This data is foundational to being able to both size the total available market for emerging technologies and develop effective, properly budgeted program pathways to serve and transform these communities. The results will help facilitate deployment of emerging technologies including heat pump water heaters, heat pump HVAC, smart plug loads, efficient appliances including induction stove-tops, home networking equipment, and other decarbonization measures. The project will leverage past studies and piggyback on existing IOU programs and contractor networks serving CA IOU DAC and HTR communities to perform targeted incremental housing condition data collection. For example, the San Joaquin Valley Disadvantaged Communities Pilot has provided initial data on home readiness for electrification and identified some initial cost needed to ready homes for electrification. The study will also use contractors to conduct in-home survey assessments and identify home that are ready for electrification and will estimate cost for those homes that require upgrades and or retrofits to allow electrification. We estimate the number of Single Family Homes in California where occupants are low-income to be 3.5 M. (Rayeff, Reem. "Housing Equity & Building Decarbonization in California." National Resource Defense Council, 2020.) We plan to create a survey for in-depth contractor assessments. This information, analyzed in combination with other data, will be used to inform the scope and nature of barriers to serving DAC and HTR communities with Emerging Technologies efforts and to develop programmatic strategies for	2022	2023

SCE Energy Efficiency Projects 2018-2022

Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET22SWE0021	ET22SWE0021 - Residential Multi-Function Heat Pumps: Product Search	Active	2022	Residential heat pump space conditioning and water heating can greatly reduce energy consumption compared to typical natural gas combustion or electric resistance equipment. Multi-function heat pumps are a product type that uses one efficient outdoor compressor and heat exchanger unit to provide both space conditioning and water heating. Multi-function heat pumps have the potential to increase efficiency and reduce cost compared to typical separate heat pumps for space conditioning and water heating by reducing the number of compressors, by recovering waste heat from space cooling to heat water, and by eliminating the need for electric resistance backup or defrost heaters. For residential heat pump retrofits, buildings often need electrical service panel upgrades that add cost and delays. Multifunction heat pumps do not need electric resistance backup or strip heaters so they can avoid the need for electrical service panel upgrades in many buildings, reducing costs for most buildings and particularly for older buildings common in California and particularly common in DAC and HTR areas. Multi-function heat pump products are currently available as custom designs using air-to-water heat pumps with cooling and heating energy carried into the building by water-glycol mixtures, but their adoption is limited by high costs. The UC Davis Western Cooling Efficiency Center (WCEC) has a PG&E funded emerging technologies project testing a lower cost and potentially higher efficiency air-to-air multi-function heat pump prototype that uses refrigerant to carry cooling and heating energy into the building. Preliminary results show that the prototype has good energy efficiency performance and that it can use waste heat from space cooling to heat hot water. This proposed technical market characterization project will complete a product search from the largest HVAC and hot water heating equipment manufacturers to identify what residential air-to-air multi-function heat pump products are commercially available or soon to be commercially available in California. This	2022	2022
ET22SWE0020	ET22SWE0020 - Variable Refrigerant Flow (VRF) Refrigerant Management Market Assessment	Active	2022	Building electrification initiatives are resulting in an explosion of electrified heating and cooling (heat pump) systems being installed in residential and commercial buildings. Electrifying the building sector is a critical step toward meeting California's decarbonization goals; however, the refrigerants used in heat pumps contain greenhouse gases (GHGs) thousands of times more warming than carbon dioxide and even methane. While keeping refrigerant from leaking into the atmosphere is critical for all heat pump applications, large commercial building systems often require extensive field-installed piping and significant refrigerant charge (amount)- a combination that creates high emissions potential. As these heat pumps, increasingly referred to as variable refrigerant flow (VRF) systems, replace fossil-fuel powered equipment in both new and existing buildings, the potential GHG impact of refrigerant leaks needs to be understood and cost-effective mitigation strategies must be incorporated into building electrification initiatives. In addition to the direct global warming impact of refrigerant leaked into the atmosphere, studies have shown that heat pump systems operating with insufficient refrigerant also consume more energy, contributing to higher electric bills and power generation emissions. This market assessment will provide clarity on anticipated market adoption of VRF systems, the lifetime GHG emissions potential of those systems if no action is taken, and the mitigation strategies that can be implemented to maximize that environmental, economic, and social benefits of commercial heat pumps. Additionally, the project will build upon and complement the current Commercial VRF Fuel Substitution measure development activity also being performed by Energy Solutions, by bringing in new market study activities including stakeholder engagement and a deeper focus on new system installations. The measure development project is focused on the measure package / work paper for VRF's using newer energy models. It is reevaluating the measure as a prescriptive offering for retrofits or gut rehab/major renovations. With this VRF Refrigerant Management market study we will review past research and lessons learned to maximize the benefits of adoption of VRF's by getting ahead of potential negative issues associated with leaks and/or improper installation and maintenance.	2022	2023

SCE Energy Efficiency Projects 2018-2022

Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET22SWE0019	ET22SWE0019 - Market Potential for Heat Pump Assisted Hot Water Systems in Food Service Facilities	Active	2022	Electrifying the building sector is a critical step towards meeting California's decarbonization goals. Water heating for food service applications represents 340M therms of gas consumption and thus presents a significant electrification opportunity through the application of heat pump (HP) assistance. For the proposed study we will conduct a market assessment of the potential for adoption of heat pump-assisted hot water systems (HPaHWS) in food service facilities. This market assessment will evaluate the total reachable market and the market penetration potential for HPaHWS. We will also address the market barriers and opportunities for adoption of HPaHWS as they currently exist. This study will occur in three phases: Literature search, Interviews, Numerical data collection and analysis.	2022	2023
ET22SWE0017	ET22SWE0017 - Commercial and MF CO2-based Heat Pump Water Heater Market Study and Field Demonstration	Active	2022	AESC proposes a California-focused market study and field demonstration of an all-electric CO2 refrigerant heat pump water heater (HPWH) designed for central systems in commercial and multi-family (MF) buildings. The technology supports electrification strategies, is highly energy efficient, capable of demand response and load shifting through use of inherent thermal storage, and uses natural CO2 refrigerants with low global warming potential (GWP). It can supply hot water up to 195° F and works in low ambient conditions with a modular design allowing up to 16 units to cover capacities from 135,000 to 2,100,000 Btu/h. The technology is commercially available and was introduced by the manufacturer within the past two years in limited markets, including New York, Massachusetts, Washington, Oregon, and Northern California. To date, it has very low market penetration in California with only a handful of new construction projects currently in design. Technology barriers include high up-front costs, lack of product awareness in the design and stakeholder community, and complexities inherent to custom design requirements of large central systems. However, sizing and design barriers are gradually being addressed through tools like Ecotope's "Ecosizer" https://calbem.ibpsa.us/resources/ecosizer/. This tool can be used for system sizing based on expected loads, building characteristics, and location but is not an energy modeling tool. Thus, it does not correlate with existing regulatory tools like CBECC. However, fundamental research into the performance of these systems in the field is needed to support future updates of CBECC and other building modeling software to accurately integrate central CO2 HPWH products. The study will build on existing research and non-residential HPWH initiatives with a focus on the California market, policies, rate structures, efficiency programs, demand flexibility programs, and market barriers. The field study will evaluate product performance and impacts on energy, cost, and green house gas emissions (GHG) of the technology relative to baseline natural gas as well as load flexibility capabilities in the context of CA rates and the new Total System Benefit (TSB) metric for EE programs. The product will be installed, monitored, and analyzed at	2022	2023
ET22SWE0010	ET22SWE0010 - All-Electric Commercial Kitchen Electrical Requirements Study Evaluation	Active	2022	This study will identify the electrical service requirements for various sizes of foodservice facilities such as quick serve, full service, cafeterias, and hospitality. This will help understand the costs, electrical load requirements, electrical service upgrade costs, and potential electrical load growth for commercial foodservice facilities in CA in converting to all-electric kitchen designs. We would work with market actors such as design / build firms to develop prototype buildings for electrical service requirements. Once the electrical service requirements have been developed for multiple prototype foodservice facilities, cost research will be completed to determine the cost of upgrading electrical service for an all-electric kitchen. Based on the electrical service requirements for the foodservice prototypes, the study will estimate the increased load associated with converting all foodservice facilities in CA to all-electric kitchen designs.	2022	2023

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Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET22SCE0008	ET22SCE0008 - Demand Reduction and Energy & Greenhouse Gas Savings in Small Convenience Stores using Artificial Intelligence technology	Active	2022	Convenience store AI based technology for field evaluation to undertand its efficacy for broader customer segment in SCE's service territory. Specifically, EPRI proposes to lead the field evaluation for Measurement and Verification of AI based technology for power reduction (demand savings) and GHG reduction at ~8-10 different customer sites across SCE's different climate zones and customer segments (small convenience stores, small/mini-markets, etc. with food storage/services). The project would be completed during an 18-month period. EPRI and SCE previously partnered and completed a "Technology Early Deployment" deliverable on this AI technology, which was also featured in EPRI's IncubateEnergy Lab Challenge. The next phase for evaluation of technology is field deployment of the technology to evaluate its efficacy for broader customer segment in SCE's service territory. Specifically, EPRI plans to lead the field evaluation for Measurement and Verification of technology for power reduction (demand savings) and GHG reduction at approximately 8-10 different customer sites across SCE's different climate zones and customer segments (small convenience stores, small/mini-markets, etc. with food storage/services). This technology is AI-driven monitoring and controls technology that reduces peak power demand by scheduling the highest-power actions in commercial refrigeration and HVAC (e.g., defrost cycles) to reduce peak demand and energy costs. By collecting data, setting up a data visualization dashboard, and developing a physics-based model of each building (a digital twin) to identify the most effective control adjustments, uses these models to run their algorithm to provide the business with improved control settings based on the region, season, and other building loads (e.g., lighting and computing). As a larger energy management platform to improve building energy management (including loads, solar, and backup power), food businesses have the opportunity for operational efficiency and savings.	2021	2023
ET22SCE0007	ET22SCE0007 - LOC-GFO-19-301-4 HP-flex: Next Generation Heat Pump Load Flexibility	Active	2022	Southern California Edison (SCE) provided a Letter of Commitment in support of LBNL's proposal for the EPIC GFO 19-301 Group 4 EPIC solicitation. The project will develop and demonstrate an open-source energy and load management system designed to control advanced heat pumps on small/medium commercial buildings. This system will minimize energy use and bills while allowing buildings to effectively participate in load shed, shift, shimmy and shape DR programs and dynamic pricing tariffs, to provide reliable and cost-effective load flexibility to the grid. Lawrence Berkeley National Laboratory (LBNL) submitted a proposal to the CEC in response to Electric Program Investment Charge (EPIC) solicitation GFO-19-301, Group 4. The proposal was awarded a contract agreement (EPC-19-013) by the CEC for a $3,000,000 grant to fund the development and field site evaluation of an open-source, scalable, low-cost control solution (called HP-Flex) for optimal demand management of high-efficiency heat pumps in small and medium commercial buildings. The goal of the CEC Agreement is to develop open-source control algorithms and educational curricula to train the next generation of engineers and technicians, to help promote the large-scale deployment of replicable, demand-flexible heat pump (HP) installations in small to medium-sized commercial buildings, to increase benefits to both individual building owners and the distribution grid compared to standard HP installations. LBNL intends to achieve these goals by focusing on a number of objectives: - Develop an advanced, integrated, open-source control system to cost-effectively provide energy optimization and load flexibility to heat pumps in small and medium commercial buildings (SMC). - Verify that HP-Flex integrated in SMC buildings can meet the following criteria: 1) Achieve a 20% reduction in site peak energy costs compared to a SMC heat pump with scheduled thermostatic control. 2) Provide 50% load shed during summer or winter peak-load events. 3) Provide 20 kWh of daily load shift capacity	2022	2024

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Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET22SCE0006	ET22SCE0006 - Advanced Energy-Efficient and Fire-Resistive Envelope Systems Utilizing Vacuum Insulation for Mobile Homes	Active	2022	CEC EPIC GFO-19-307 -Mobile homes are lagging in terms of energy efficiency requirements with associated high energy consumption and greenhouse gas emissions. Mobile homes are disproportionately located in disadvantaged and low-income communities, and residents face outsized energy bills and increased wildfire risk. Initial calculations show a average site saving of 49% (kwh) and 494 lbs of CO2e avoided/yr across all California Climate zones.	2020	2024
ET22SCE0005	ET22SCE0005 - Dual-Purpose – Heating & Cooling – Thermal Battery for Flexible and Energy Efficient Heat Pump Systems	Active	2022	University of Maryland (Prime), EPRI, Sunamp, Heat Technologies, ORNL, Rheem is developing a technology consisting of a dual-purpose (heating and cooling) thermal battery with room temperature storage integrated with heat pump(s) (HP's), for both residential and commercial applications. The thermal battery serves as the heat reservoir that absorbs heat when operating as condenser in cooling mode or rejects heat when operating as evaporator in heating mode. The system may be configured as a single HP with one compressor (preferably two-stage) or two compressors, or two separate HP's with dedicated compressors.	2022	2024
ET22SCE0004	ET22SCE0004 - Cascade thermoelectric heat pump with vapor compression heat pump	Active	2022	The proposed technology is a residential/ small commercial heat pump (~3-5 tons capacity) that cascades a thermoelectric (TE) heat pump with a conventional air-source heat pump. This heat pump will (a) Boost capacity and COP at colder outside air temperatures, (b) Reduce peak demand by eliminating electric resistance (strip heat) or backup heating and (c) improve efficiency by ~10%.	2022	2024
ET22SCE0003	ET22SCE0003 - Acoustic drying for Industrial Processes	Active	2022	The day-to-day operations of printers and converters are driven by the many variables of press operation, the need for quality, speed and low production costs including energy efficiency. These operations use solvent- or water-based inks and adhesives that require some method of drying other than ultraviolet (UV) or electron beam (EB) curing materials, which are cured using mercury lamps or an electron beam. Solvent-based ink and adhesive technologies have their own regenerative thermal oxidizer (RTO, or incinerator), associated maintenance costs, and environmental compliance requirements that have become even more complex as the world moves toward the use of more sustainable materials. This project is focused on testing new Acoustic Drying (AD) processes at two businesses located in SCE service territory. Test sites will be chosen to replace existing gas or electric based curing processes, and to provide a hybrid approach where only part of the process is replaced with AD.	2021	2024
ET22SCE0002	ET22SCE0002 - Heat Pump Rating Representativeness Validation Project	Active	2022	The Advanced Heat Pump Coalition is a group of utility and energy efficiency interested parties that has agreed to share knowledge and align efforts to have biggest impact on HVAC industry efforts that help utilities accelerate market adoption of residential heat pumps. The Advanced Heat Pump Coalition is conducting the Heat Pump Rating Representativeness Validation Project. Project will be managed by the Northeast Energy Efficiency Partnership (NEEP) with advisory group of funders. NEEP will issue RFP to hire a contractor to conduct research and analysis. NEEP point of contact is David Lis (NEEP), Co-coordinator is Christopher Dymond of Northwest Energy Efficiency Alliance (NEEA). This will be a field test of heat pump in six identical test sites over heating and cooling seasons with research level accuracy designed to remove independent variables (homeowner behavior, home differences, thermostat differences, climate differences, etc.) that plague typical heat pump field tests. Project timeline: Q3 2021 – Q4 2022 The project goal is to validate and evaluate heat pump rating representativeness (lab test to field performance accuracy) of two different heat pump ratings. The two different test procedures are CSA EXP07 which generates SCOP values, and the Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps (Appendix M1 to Subpart B of Part 430) which generate SEER2 and HSPF2 values. The project will also generate research quality data across a wide range of outdoor conditions that it can be used in other HVAC applications and test procedures.	2021	2022

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Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET21SCE8040	ET21SCE8040 - Very High Efficiency HVAC for Commercial Office Building	Active	2021	Provide a demonstration project for commercial customers in SCE territory. This demonstration would replace ISP air conditioning systems with Variable Refrigerant Flow (VRF), Dedicated Outside Air Systems (DOAS), and Energy Recovery Ventilation (ERV).	2021	2023
ET21SCE8010	ET21SCE8010 - Quick Building Electrification Modeling Tool	Active	2021	Funding support for the development of a quick software tool that provides life cycle cost analysis of a suite of building electrification, PV, battery storage. Primary target is commercial building types, but residential will be included.	2021	2022
ET21SCE1010	ET21SCE1010 - CARB, NASRC and SCE M&V Evaluation of Low GWP Supermarket Refrigeration Systems	Active	2021	The legislature awarded the California Air Resources Board (CARB) one million dollars in the 2019-2020 budget to create the SB 1013 Fluorinated Gases Emission Reduction Incentive Program, or F-gas incentive Program (FRIP). FRIP seeks to alleviate the barriers to the adoption of climate-friendly technologies, namely the higher incremental cost and lack of familiarity. Funding is restricted to existing and planned retail food facilities, which are among the largest sources of high global warming potential (GWP) F-gas emissions. As part of the effort for encouraging end-user adoption of new technologies, EP&T will confirm the new systems that will be installed are more energy efficient.	2021	2024
ET21SCE0021	ET21SCE0021 - TTC Dynamic HVAC Test Chamber	Active	2021	The SCE's Technology Test Centers (TTC) evaluate a variety of technologies in controlled environments that mirror real-world conditions and customer experiences. This generates comprehensive performance data and innovative test methods which are used by SCE customers, policymakers, and utility programs to make informed decisions regarding the investment and application of cleaner technologies. The current ratings for residential/small commercial HVAC systems are based on steady state lab test methods that are not sufficiently representative of field performance. Dynamic testing or load-based testing is necessary to better characterize the performance of the actual advanced controls of these heat pump systems. TTC seeks to build a test chamber capable of advanced dynamic HVAC testing at the facility in Irwindale, CA. Current TTC HVAC lab test capabilities are limited to steady state methods that disable native HVAC controls. A dynamic test method, such as CSA EXP07, produces metrics/results that include operation of native controls. It is important to find out if HSPF2 and SEER2 or SCOPh and SCOPc provide ratings representative of field performance when equipment is operated under its own controls and under loads that vary with ambient temperature. Additionally, the test chamber could also be used to test small commercial self-contained refrigeration equipment.	2021	2023
ET21SCE0020	ET21SCE0020 - Electric Disinfection Technologies	Active	2021	In response to COVID-19, commercial customers are seeking methods to safely return occupants to their buildings. This lab study will provide efficacy of several in-room light-based disinfection techniques.	2021	2022
ET21SCE0018	ET21SCE0018 - Residential Water Heating Cost Comparison Tool/Calculator	Active	2021	Develop a tool that assesses energy, emissions, and operating cost for different types of domestic water heating technologies. It will include analysis for the tool and will also assess water heater operation with and without rate responsive load shifting capabilities.	2021	2022
ET21SCE0016	ET21SCE0016 - 120V Heat Pump Water Heater Consolidated Field Study	Active	2021	120V HPWH products are completing lab (UL) testing at this time and are expected to be available for field testing in Q1 2021. A field study of 8 units in SCE service area using 120V products will enhance the understanding of how the products perform and how they can be deployed. This field study is part of a broader statewide effort consisting of 36 units.	2021	2023
ET21SCE0015	ET21SCE0015 - Smart Electrical Panel Market Characterization Study	Active	2021	Market research and characterization of smart electrical panels to assess industry with the objectives of energy efficiency, GHG/Decarb reduction, DSM flexibility, building and transportation electrification.	2020	2023

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Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET21SCE0014	ET21SCE0014 - Demonstrate Smart Exterior Solid-State Lighting in Low-Income or Disadvantaged Communities (EPRI)	Active	2021	GFO-20-303 Group 3 - Address the problem of poor exterior lighting conditions in low-income and disadvantaged communities by developing, testing, and demonstrating a reliable, affordable, hybrid solar LED light that optimizes charging based on grid conditions while providing deep energy savings.	2020	2023
ET21SCE0012	ET21SCE0012 - Low-GWP Refrigerant Remodel Energy Impact Case Studies	Active	2021	The project will consist of an assessment of energy and non-energy impacts of low-GWP retrofits on three supermarkets. Each of the three supermarkets are scheduled to upgrade their existing systems, replacing traditional HFC refrigerants with low-GWP (less than 150) and reduced charge moderate-GWP systems (less than 1500). Data collected pre- and post-retrofit will be used to quantify energy impacts at each site through a combination of short-term logging, spot measurements, controller trend logs, and whole building energy consumption data. This data, and observations at sites will be used to calculate end use consumption of the primary systems and assess the impact of various design changes at each store.	2020	2023
ET21SCE0011	ET21SCE0011 - Low-GWP Refrigerant New Construction Energy Impact Case Studies	Active	2021	The project will consist of an assessment of energy and non-energy impacts of moderate-low GWP refrigeration design on three newly constructed supermarkets. Each of the supermarkets will be newly opened and operating as of August 2020 with low-GWP (less than 150) and moderate-GWP systems (less than 1500) prior to the start of this study. Data collection will be limited to post-installation and will be used to quantify energy impacts at each site through a combination of controller trend logs, whole building, and sub-metered energy consumption data. This data and observations at sites will be used to calculate end use consumption of the primary systems and assess the impact of various design strategies at each store relative to a “standard-practice” hypothetical baseline and each of its counterparts.	2020	2023
ET21SCE0010	ET21SCE0010 - Integrated Process Heat System for Textile Application, Waste Heat Recovery, Solar Thermal, Storage, and ORC - EPRI proj ID: 1-114480	Active	2021	A large majority of industrial facilities in California generate heat as part of their manufacturing processes. Much of this heat is rejected into the environment at varying temperatures above the ambient levels. This project will demonstrate and evaluate the integration of waste heat technologies, state of the art solar thermal collectors, hot storage and an ORC to improve overall system efficiency and drastically reduce GHGs.	2021	2023
ET21SCE0009	ET21SCE0009 - Commercial Foodservice Holding Bins	Complete	2021	Foodservice equipment verify efficiency testing to develop a Deemed Measure Offering for Commercial Hot Food Holding Bins used in restaurants, especially quick service restaurants, to hold cooked ingredients for assembly at food safe temperatures with establish ASTM standards.	2021	2022
ET21SCE0008	ET21SCE0008 - Non-Buoyant Oxygen Infusion System Project & Measurement	Complete	2020	Perform measurement and verification of NanO2 aeration technology to reduce wastewater treatment plant blower load while eliminating sewer system odor and corrosion.	2020	2021
ET21SCE0005	ET21SCE0005 - Technology Acceleration Project	Complete	2021	Accelerated process of evaluating potential deemed or custom energy efficiency (EE) measures, by working with SCE's Engineering Review & Analysis (ERA) team and Business Customer Division (BCD). ET field evaluation will be combined with a custom EE project, to determine if timeline for measure adoption can be decreased.	2021	2022

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Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET21SCE0004	ET21SCE0004 - Empowering Energy Efficiency in Existing Big-Box Retail/Grocery Stores	Active	2021	As part of EPIC GFO 16-304/EPC-17-008 Center for Sustainable Energy along with their project partners will design and demonstrate the impact of an integrated suite of energy efficiency technologies in an existing Big Box retail store. The technologies include lighting upgrades, HVAC/refrigeration controls, and a novel supervisory controller that provides whole-building optimization that results in a reduction of electricity consumption at subsystem levels. The goal of the project is to demonstrate that the technology package will achieve site electricity savings of >20% behind-the-meter. The resulting data (measured and modeled) will be used to validate the demonstrated technologies' performance and move them into the mainstream market. The project results can be replicated and deployed in other buildings across California with similar end-use and system characteristics.	2017	2023
ET21SCE0003	ET21SCE0003 - CSUDH Solar Thermal Integrated Supplemental Process Heat Evaluation	Active	2021	Evaluation of solar thermal system integrated with campus central plant hot water loop. Target temperature for the supplemental solar thermal array is 160'F and will eliminate most of the existing heat provided by the boilers and the central plant. CSUDH is part of the CEOP pilot to minimize GHG emissions, including improving overall energy efficiency for the campus. Analysis will be performed for the economic and efficiency opportunities in an efficient system comprised of heat pumps and solar thermal to entirely replace the existing high efficiency gas boilers.	2021	2022
ET21SCE0002	ET21SCE0002 - San Bernardino Valley College TEC Project-Sustainable Innovations	Active	2021	The SBVC Automotive TEC project is a Net Zero Pilot project. The project is intended to be a model for future Community College capital projects and also serve as living laboratory. The project includes several sustainability innovations. These include: 1. Air Handling Unit Condensate Recovery system; 2. Solar Chimney; 3. Atmospheric Water Generator; 3. Phase Change Material; 4. DC Demonstration; 5. Battery Storage; 6. solar glass 7. Solar Canopy 8. Battery Storage; 9 Interactive sustainability kiosk. The sustainability strategies and innovations in the building to teach occupants about the merits and impact of solid sustainable design. The data from each of the strategies in the building will be routed through the Building Management System and then conveyed to a sustainability kiosk in the main lobby of the building so that students, faculty and visitors alike can use the building as a teaching and learning tool.	2021	2024
ET21SCE0001	ET21SCE0001 - San Bernardino Valley College - Solar Chimney Study	Active	2021	Solar Chimney Design as part of the SBVC Automotive TEC Project. A solar chimney is a passive solar ventilation system. It is a way of improving natural ventilation within a building as well as providing heating or cooling by utilizing heat from the sun to enhance natural stack effect ventilation through a building. At SBVC TEC, 5 solar chimneys are placed along the spine of the building. The solar chimneys reduce the demand on the HVAC system to cool the spaces, which in turn results in greater energy efficiency and thermal comfort. During cooler times of the year, the solar chimney outlets can be closed, resulting the containment of hot air. This hot air will passively heat spaces below and will reduce the demand on the HVAC system as well.	2021	2024
ET20SCE8030	ET20SCE8030 - Market Characterization of Indoor Cannabis Cultivation	Complete	2020	Market Characterization of the indoor agriculture market, future outlook, and savings potential. To address challenges of climate variability, population growth, and land use, there have been efforts to grow more products in urban areas. Indoor farming is becoming more common but come with various challenges, most of which relate directly to electricity consumption.	2020	2021
ET20SCE8020	ET20SCE8020 - Water Heating and Space Heating Technologies: Comprehensive Matrix Development	Complete	2020	Create comprehensive matrix of available space and water heating product offerings. The matrix will be utilized for energy efficiency program design and SCE's building electrification efforts. This effort will support SCE's Pathway 2045 goals to electrify buildings.	2020	2020

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Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET20SCE8010	ET20SCE8010 - Residential Direct Install Back-casting & Avoided Cost Analysis	Active	2020	This project will conduct an analysis of a backcasting analysis tool targeted at the Residential Direct Install program which offers a focused package of measures for residential energy efficiency. The tool presents a unique opportunity to directly gauge the combined benefits that could be achieved through an integrated EE/DR program, and to compare those benefits to the isolated EE intervention. The analysis will also assess the impact on savings and cost-effectiveness of various targeting strategies based on customers' pre-program usage characteristics. This backcast can help assess the potential improvements from targeting and identify the most effective strategies.	2020	2022
ET20SCE7070	ET20SCE7070 - High Performance Air Filter Evaluation	Active	2020	Identify and evaluate EE measures associated with Commercial Customers' desire to mitigate COVID-19 infection rates within their occupied buildings. These EE measures will include, but not be limited to, timed control of portable fan/filter and fan/UV light plug-in appliances, and needlepoint bi-polar ionization.	2021	2022
ET20SCE7060	ET20SCE7060 - Artificial Intelligence, Energy Efficiency Demonstration and Performance Evaluation for Campuses	Active	2020	Work with campus engineering personnel to collect pertinent energy, temperature and fluid flow data for analysis. Identify all data sets and points that can effect Plant and Building efficiency and continued performance. Then determine the most appropriate BAS platform to pull all of the data together. Create simulation model(s) using points and data sets to fully understand what effect they have on the campus systems.	2020	2022
ET20SCE7050	ET20SCE7050 - Market Characterization of Indoor Agriculture (Non-Cannabis)	Complete	2020	Market Characterization of the indoor agriculture market, future outlook, and savings potential. To address challenges of climate variability, population growth, and land use, there have been efforts to grow more products in urban areas. Indoor farming is beco more common but come with various challenges, most of which relate directly to electricity consumption.	2020	2021
ET20SCE7040	ET20SCE7040 - Study to Determine Optimum Replacement Refrigeration System for Production Bakery	Active	2020	Study Replacement of R-22 and R-410 refrigeration systems with R-717 based system at Production Bakery. This study will look at available refrigeration systems, both packaged and field erected, the meet current California regulations regarding refrigerants and that are the most energy efficient.	2020	2022
ET20SCE7030	ET20SCE7030 - Grid-Interactive Efficient Building (GEBS)	Active	2020	This a technical demonstration for"Grid-Interactive Efficient Buildings (GEBS)" within the SCE's territory supporting General Services Administration's (GSA) and DOE High Impact Technology Innovation Catalyst (HIT Catalyst) programs. The project will initiate a software application gateway to integrate existing and new solutions supporting Energy Efficiency, DERs, Flexible DSM to Grid interactive strategies, building electrification, energy impacts analysis and potential GHG reductions.	2020	2023
ET20SCE7020	ET20SCE7020 - Indoor Horticulture Field Lighting BCD/CP&S Demonstration	Active	2020	Field demonstration of Indoor Horticulture Lighting system (HID to LED)	2020	2023
ET20SCE7010	ET20SCE7010 - California Advanced Water Heating Initiative	Complete	2020	The objective of this advanced water heating initiative is to overcome market barriers and challenges associated with HWPHs through the development of a coordinated, statewide effort and alignment of existing and new programs, policies and technologies. The initiative will increase the adoption of high efficiency heat pumps.	2020	2021

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Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET20SCE1070	ET20SCE1070 - Field Evaluation of Small Wall Mounted HPWHs	Active	2020	Field evaluation, in three commercial sites, of a small wall-mounted heat pump water heater. This follows an EPRI lab evaluation of the same product. This equipment is not currently available in voltages employed in the United States, and isn't UL Listed. Research questions: • Can these products meet U.S. residential and light commercial water heating needs, or are small modifications needed to provide competitive performance (e.g., larger resistance element)? • What are site-specific constraints that must be overcome? • How do hot water usage profiles vary (e.g., by time of day, by household occupancy, single family vs multi family, etc.) • How will occupants react to a more efficient water heater with less storage capacity and smaller electric element? Will performance be considered acceptable? • Are costs for a contractor-installed mixing valve of value in order to provide a higher level of storage energy to help meet hot water loads?	2021	2022
ET20SCE1060	ET20SCE1060 - HVAC Supply Air Phase Change Material	Active	2020	Lab or field test of phase change material (PCM) installed in air conditioning systems' supply air duct. PCM freezes during off-peak periods, then melts to offset compressorized cooling during peak hours. $47,000 included labor and materials to install Stasis on a customer site, on a 5 ton AC system. Other options will cost less.	2020	2022
ET20SCE1050	ET20SCE1050 - Measuring Builder Installed Electrical Loads	Active	2020	The aim of this sub-project is to collect data on electricity consumed by equipment in newly-constructed homes that are either required by health and safety codes or are considered necessary to make the house attractive to buyers. This aspect of residential energy use has not been studied but anecdotal measurements from an ongoing EPIC project suggest that builder-installed loads are responsible for as much as 1300 kWh/year before occupants have moved in.	2020	2022
ET20SCE1030	ET20SCE1030 - Campus All Electric Foodservice Facility @ CSUDH Innovation & Instruction Building	Active	2020	Innovation & Instruction Building in construction at the campus was originally specified with gas ovens, cooktops, combi ovens, and fryers. Project is to specify and replace gas equipment, modify design for all electric equipment that will replace the gas counterparts. Adjust ventilation requirements as necessary. In addition, replace original walk-in coolers and freezers to meet requirements for new CARB limits for GWP in 2022. Replace gas water heating with HPWH. Building will open in 2nd quarter of 2021. We will use modeling tools and instrumentation of the installed equipment to determine energy savings, air quality benefits, and better work environment.	2020	2023
ET20SCE1020	ET20SCE1020 - Smart Grid-Connected Transit Hubs	Active	2020	The state of California has identified vehicles as the largest source of Green House Gas(GHG) emissions. Traffic and congestion are a part of living and working in Southern California, especially on the west side around Santa Monica. "Silicon Beach" is growing and adding to the environmental, commuting and parking struggles in the area. This project is a joint effort between SCE, UCLA, LA Metro and local real estate developers who are trying to ease these struggles and manage energy resources. This opportunity to demonstrate with the project partners how real estate owners can benefit from a "Smart Electric Hub." It also demonstrates how to use customer side of the meter resources, help SCE manage the added load from multiple forms of charging of vehicles, including fast chargers.. This demonstration project can scale the use of light rail, electric buses and other forms of transportation, providing the cleanest method for First -Last mile strategy for transportation needs and reducing GHG.	2020	2023
ET20SCE1010	ET20SCE1010 - Rapid Energy Model Development for Residential Energy Simulation Phase 2	Complete	2020	This is a follow up of an assessment of a web-based, energy efficiency recommendation engine providing a customized "path to zero-net energy" for any existing home. This tool uses current technologies in building energy simulation and combines it in a novel way with other recent developments in 3D building data from aerial photography and cloud computing, to develop individual 'energy models' of each home. This project aims to assess adding additional energy use data and/or home energy audit information to the data set to improve the reliability of recommendations.	2020	2022
ET19SCE8050	ET19SCE8050 - Heat Pump Water Heater Systems Lab	Active	2019	Provide a scalable testing platform to support the evaluation of existing and emerging standards of HPWH's communication, Efficiencies and performance capabilities	2019	2023

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Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET19SCE8040	ET19SCE8040 - Grid Integration of BE Retrofits at Community Scale	Active	2019	The primary purpose of this study is to evaluate the impacts of an all-electric retrofit home community(s) on the local distribution systems.	2019	2023
ET19SCE8030	ET19SCE8030 - Market Characterization Study of Commercial Buildings	Complete	2019	This project is a market study aimed at providing insight into the opportunities for reducing GHG emissions for Commercial Buildings by identifying new technologies to support the electrification of buildings. These technologies have an impact on the energy use and efficiency of a building in which this study may provide potential measures.	2019	2020
ET19SCE8010	ET19SCE8010 - Evaluation of DEER2020 Tier Requirements in Support of Upstream Chiller Performance Data and Workpaper Development	Complete	2019	Gathering of Upstream Chiller performance data to enable performance curves to support the evaluation of Non-DEER Chiller measures. This work is expected to allow an increase in program participating by facilitating evaluation and deemification of high performance equipment currently not supported by DEER.	2019	2020
ET19SCE7110	ET19SCE7110 - Large Capacity CO2 Central Heat Pump Water Heating Technology Evaluation and Demonstration	Active	2019	The overall goal of this project is to promote low GWP water heating technologies for central system applications typically found in multifamily and commercial buildings, increasing load shifting capabilities using central water heating systems, and developing best practice guides that simplify the design and installation of these systems.	2019	2024
ET19SCE7100	ET19SCE7100 - Demonstration of Radiative Sky Cooling System (EPIC)	Active	2019	Roof mounted, radiative sky cooling panel has a specialized film that cools when outside. These panels cool with minimal electricity, all day long throughout the year without evaporating water. The panels can be integrated into any new or existing refrigeration/HVAC system as an efficiency add-on for reducing electricity, water usage and GHGs from the cooling equipment.	2019	2023
ET19SCE7070	ET19SCE7070 - Walk-in Coolers/Freezers low GWP and EE performance assessment (SCE-CARB-CTS collaboration)	Complete	2019	To help California reach SB1383 short-lived climate pollutant goals, this project will demonstrate the energy efficiency and environmental benefits of low GWP refrigerant based systems for walk-in freezers and coolers. There are thousands of these units that keep food product at the right temperature for public safety. It is believed by the project team that there are opportunities for retro-fit of existing equipment that will allow for energy efficiency and CARB low-GWP incentives. This project will help determine what the benefit can be. Also, demonstrate how technologies can be incented for energy efficiency and for GWP reduction through the CARB.	2019	2022
ET19SCE7060	ET19SCE7060 - Indoor Ag Technology Demonstration	Active	2019	Demonstration platform to educate and demonstrate multiple emerging technologies for Indoor AG solutions	2019	2023
ET19SCE7050	ET19SCE7050 - Evaluation of Large Heat Pumps for Building Hydronic Heating	Active	2019	This project seeks to evaluate a new technology being developed by leading manufacturers, that employs a high-lift centrifugal vapor compression to address the large building air-source hydronic heating market. This product seeks to replace fossil fired boilers in large buildings that currently do not have a clean efficient electric solution.	2019	2022

SCE Energy Efficiency Projects 2018-2022

Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET19SCE7020	ET19SCE7020 - Ultraviolet-C (UV-C) LED for Wastewater Germicidal Irradiation (UVGI)	Complete	2019	Ultraviolet-C (UV-C) LED for Wastewater Germicidal Irradiation (UVGI) Much like light-emitting diodes (LEDs) have revolutionized the general (visible spectrum) lighting industry, UV-C LEDs are set to rapidly replace conventional UV mercury vapor lamps in water disinfection and water reuse applications. Although it is generally accepted that UV-C LED technology can be used for various water disinfection uses, steps need to be taken to verify performance and determine scale-up factors to support technology transfer to the high-throughput levels of municipal drinking water and wastewater systems. To this end, EPRI aims to evaluate the disinfection performance, reliability, and energy use requirements of small- scale, UV-C LED pilot units against contaminants commonly found in municipal drinking water and wastewater. Does UV-C LED technology perform like conventional UV mercury vapor lamp systems in water disinfection applications?	2019	2021
ET19SCE7010	ET19SCE7010 - NMEC Pre-Qualification Analysis	Complete	2019	This Project is aimed at a set of customers that do not have the appropriate SCE EE Offering to accomplish their goals. Specifically, the Project will allow chain-type commercial customers with similar buildings to implement the same set of measures at each site. Identical projects at near-identical sites, with identical NMEC performance calculation procedures, will allow for SCE and CPUC review to be streamlined, as it is applied to "batches" of projects at the program approval stage. After approval, each site will be put on its own individual meter-based, pay-for-performance EE project structure, as opposed to calculating performance across aggregated sets of sites, or "rubber-stamping" savings estimates from one site onto another without measuring.	2019	2020
ET19SCE1160	ET19SCE1160 - Advanced High Temperature, Low Pressure Steam Heat Pump	Active	2019	Replace low pressure, saturated natural gas fired steam boilers, with two stage heat pump system. Provide first stage heat pump for high temperature hot water needs for sterilization and, and then use second stage for steam needs of the bakery. Use of advanced heat pumps with low GWP refrigerants will provide very efficient methods for providing process heat.	2019	2024
ET19SCE1150	ET19SCE1150 - Efficient Electrification opportunities for Breweries and Wineries	Complete	2019	Survey of Craft Brewing Industry Identify common brewery configurations, typical equipment needs, process and operational characteristics through internet research, phone interviews, and site visits with end-users to characterize the energy and water intensity of the craft brewing industry.. Survey of Technologies Identify technologies and manufacturers providing innovative solutions for energy efficiency and electrification in breweries. Case studies and existing assessment efforts to be identified, with associate data / findings collected as available. 3. Survey of Related Beverage Industries (optional task) If five or more participants join the collaborative, expand survey to include related industries, such as wineries and/or craft distilleries, as guided by the participants. Identify commonalities with the brewing industry, and compare opportunities between the industries to direct engagement efforts. 4. Technology Assessment Review data gathered in Tasks 1, 2 and 3 to assess the energy, demand, water, and emissions impacts, and analyze the cost impacts of the technologies identified. 5. Technology Transfer Periodic reporting of project status and findings through regular conference calls and webcasts. A final report to be prepared that summarizes project findings, along with an executive summary presentation in PowerPoint format.	2019	2021

SCE Energy Efficiency Projects 2018-2022

Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET19SCE1140	ET19SCE1140 - Electric High Capacity Forklift Demonstration	Active	2019	In order to quantify the impacts of electric forklifts in outdoor applications and dispel the perception / misconception that electrics cannot perform in outside settings and adverse weather, EPRI intends to conduct electric outdoor forklift demonstrations at various locations. New learnings will be realized by quantifying actual data collected from end use customers through data collection on each truck and analysis of this data from each demonstration. Estimates of overall impacts for an outdoor application will be researched and documented for use Supplemental Project Agreement 11/12/19 Page 2 Agreement No. 20008972 – Project ID No. 1-111087 by end users across the country. Any benefit from the research that a funder receives is incidental to the benefit received by the interested public. This project is planned to have one funder to be the host site provider with a minimum of three additional participants. The project objectives are: · To gain and understand new learnings within the 15,000 pound (or more) outdoor capable electric forklift market through a demonstration of outdoor electric trucks performance compared to their internal combustion truck counterpart and quantifying the impacts of electric compared to the conventional fuel. · Characterize the forklift and monitor its kW use, kW demand, kWh, load factor, energy profile over time of charge, V, I, pf, Battery Voltage, Battery A-hrs., and Battery State of Charge (SOC%) over the course of the test · Conduct the field demonstration for a period of minimum six months. · Document our demonstration, data, potential impacts and findings and share the results with the funders. · Understanding the market for high capacity forklifts that are over 15,000 pounds. · Produce audio/video materials for eliminating the common misconceptions among customers	2019	2022
ET19SCE1120	ET19SCE1120 - High Efficiency All-Electric Truck & Trailer Refrigeration Unit Plug Load Evaluation	Active	2019	Work with local refrigerated truck fleet to demonstrate energy demand profiles, costs and benefits. Use plug-in capabilities, truck/trailer mounted PV, batteries, to demonstrate environmental and cost benefits of using electric powered TRus as much as possible. Substitute R-404A refrigerant with drop in replacement to demonstrate impacts to efficiency of TRu and ability to operate on electricity by characterize the energy and GHG impacts.	2019	2023
ET19SCE1110	ET19SCE1110 - Refrigerated display cases air curtain guiding vanes	Active	2019	Emerging technology evaluation of refrigerated display case shelf edge guiding vanes. This technology is applicable to all users of open medium temperature refrigerated display cases. Sectors include supermarkets, and convenience stores. Any cold merchandising that utilize an open display case applies.	2019	2022
ET19SCE1100	ET19SCE1100 - Grid Responsive Heat Pump Water Heater (WH) Study	Active	2019	As part of SJV Pilot, SCE included a study to deploy HPWHs equipped with communication technology that will allow the water heater to be used as a grid-responsive heating technology element of the pilot to electrify homes and reduce emissions within the SJV. SCE hopes to gain insight into how aggregated distributed resources can be used to benefit the grid and simultaneously offer residents the ability to manage energy consumption through time-of-use (TOU) management of their energy consumption. This study will only be conducted in 12 residential single-family dwellings of customers participating in the SJV Pilots.	2019	2024
ET19SCE1090	ET19SCE1090 - Nano2-Non-Buoyant Oxygen Infusion Treatment	Complete	2019	Perform measurement and verification of NanO2 aeration technology to reduce wastewater treatment plant blower load while eliminating sewer system odor and corrosion.	2019	2020
ET19SCE1080	ET19SCE1080 - Laboratory Evaluation of Small Wall-Mounted Heat Pump Water Heaters	Active	2019	The objective of this project is to evaluate the performance in the laboratory of two small wall-mounted Heat Pump Water Heaters from Europe and their ability to provide hot water in a more efficient manner and with lower total emissions. The HPWHs are commercially available in Europe, however,these units have not yet been tested by U.S. test standards to determine the uniform energy factor (UEF) or first hour rating (FHR). Prior to selling these units in the U.S., these units will have to be converted to 60 Hz , tested to slightly higher water test pressure than in Europe. UL certification will also be required.	2019	2022
ET19SCE1070	ET19SCE1070 - Commercial Heat Pump Water heater Evaluation	Active	2019	The objective of this project is to evaluate the performance in the laboratory of a new-to-market 120-gallon commercial Heat Pump Water Heater and its ability to provide hot water in a more efficient manner and with lower total emissions. This water heater has a COP of 4.2	2019	2022

SCE Energy Efficiency Projects 2018-2022

Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET19SCE1060	ET19SCE1060 - Refrigerated Warehouse/Plant Automated Energy Scheduling, Optimization and Control	Active	2019	Optimize central plant efficiency for industrial refrigerated warehouses. Then analyze the data and determine control changes that will minimize compressor operation and maximize plant output. Install sensors through warehouse to understand air flow and thermal distribution within each refrigerated space to maintain product quality and safety.	2019	2022
ET19SCE1050	ET19SCE1050 - Evaluation of Direct Energy Savings and Demand Response Potential from PCM for Cold Storage Cooling Applications	Complete	2019	This project will help determine the effectiveness of Phase Change Materials (PCMs) in cold storage applications at Low Temperature -10 - 0 F (-23 - 18 C). Controls will also be implemented into the study to determine how compatible it is with PCMs. A total of 4 tests will be done on warehouses to see if PCMs have an impact on energy savings, demand response and keeping the temperature at appropriate levels. The main research objective is to evaluate the effectiveness of PCM separately from the controls. We want to determine if it was either PCM or Viking cold's controller that played a bigger role in energy savings. The purpose of this project is to explore the demand response potential from phase change materials for cold storage applications to SCE: 1. Critical peak load reduction – Can PCM be used to reduce electric loads in cold storage applications during critical peak load conditions? 2. Required notification times – Can cold storage loads with PCM reduce critical peak loads with day-of notification or do they require day-ahead notification? 3. Consistency of critical peak load reduction – Can cold storage loads with PCM respond to event notifications over successive days (3 or more days in a row)?	2019	2021
ET19SCE1040	ET19SCE1040 - Electrochromic Window Film	Complete	2019	To test the performance of Electrochromic/Smart Tint Windows, A test apparatus box will be made to simulate a space. Using a spectrometer and simulated light (Halogen light) to capture the wavelengths. This will help determine whether or not the window film will block out any infrared radiation. Other datapoints such as luminosity and temperature will be gathered. This project is to work closely with LADWP in order to build the test apparatus and procure test samples of window films. The main goal of this project is to determine if window films are effective at blocking the sun while maintaining acceptable light levels in the room while also keeping the room cool in order to save energy on HVAC.	2019	2022
ET19SCE1020	ET19SCE1020 - Smart Speakers Assessment	Active	2019	SCE is conducting a smart speaker demonstration study in which it will install a home automation gateway, smart thermostat, smart plugs, smart light bulbs and a smart speaker at selected customer homes. This equipment will allow SCE to monitor the energy use of the installed products and optimize some connected devices based on residential TOU rates and customer preferences. Customers will set preferences, ask energy related questions and receive answers using a smart speaker. The will help in understanding customer Behavior which can lead to other phases on the project in a larger scale. The results of the demonstration project could inform the design of future technology-enabled customer programs from SCE that can help customers reduce energy use and costs. SCE will endeavor to notify participating customers of subsequent program opportunities if they arise.	2019	2022
ET19SCE1010	ET19SCE1010 - Evaluation of central air-source CO2 heat pump water heating system in Multi-Family	Active	2019	Design and pilot of a central CO2 heat pump water heating (HPWH) system and measurement & verification (M&V) work at the proposed 117-unit, 157,000 SF Culver City Senior Housing development. The project includes primarily independent living apartments with efficiency kitchens and a large central commercial kitchen and dining facility.	2019	2023
ET19SCE0002	ET19SCE0002 - LOC-GFO-19-301-1 Advanced Air-to-Water Heat Pumps Space Conditioning Systems (ET)	Active	2019	This project will develop high efficiency air-to-water heat pump technologies, and further develop low-cost, polymer water-to-air heat exchangers that have improved performance (effectiveness/pressure drop) at lower cost. System will have a primary loop consisting of flammable low GWP refrigerants and secondary loop using water. Utilize primary secondary loops to isolate flammable refrigerants. Additional thermal storage capabilities to manage load shift as well as domestic hot water.	2021	2023

SCE Energy Efficiency Projects 2018-2022

Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET19SCE0001	ET19SCE0001 - LOC-GFO-19-301-1 A zero GWP heat pump and distribution system for all-electric heating and cooling in California	Active	2019	Develop, test and demonstrate an advanced zero GWP space conditioning system for multi-family or small commercial applications that is based on a reversible ammonia (NH3) heat pump with carbon dioxide (CO2) distribution, for space heating and cooling applications. A prototype of this technology, delivering space cooling only, was successfully tested at the EPRI lab in Knoxville in 2018-2019. The proposed project, will extend the technology to space heating, optimize the performance of the system, and develop a roadmap for its commercial development. SDGE ($200K), TVA ($40K), Southern Co ($40K) will be providing financial cost share.	2019	2023
ET18SCE8010	ET18SCE8010 - Smart Street Light Poles Demonstration	Active	2018	This project is aimed at demonstrating new services and benefits of LED Street Lighting including new technologies that can integrate with LED Controls/Remote Monitoring to provide additional functionality and capability. These additional capabilities include signage, cameras, microphones, environmental sensors and charging of devices.	2018	2023
ET18SCE7080	ET18SCE7080 - Next Generation Low-GWP Refrigeration Systems; Tools Assessment and Market Impacts	Complete	2018	Research existing modeling tools used for estimating refrigeration system performance for supermarkets. Once the background study is completed, assemble and review results. Then recommend which tools are publicly accessible and recommend modifications to allow tool to estimate performance of systems utilizing natural refrigerants.	2019	2019
ET18SCE7070	ET18SCE7070 - Wastewater Treatment and Process Water Recycling Systems	Complete	2018	This Project proposes to demonstrate the benefits of the installation of a wastewater treatment system designed to reduce the amount of energy and water consumed at a dairy. The demonstration results will identify pumping energy reduction, water savings, reduced water intake from wells through the reuse of recycled water, and GHG opportunities. The Project will outline the treatment requirements based on sizing calculations conducted in the system design, commissioning and M&V data collections.	2018	2020
ET18SCE7060	ET18SCE7060 - Agriculture Lighting Applications	Active	2018	"Indoor Horticulture utilizes electric (also known as artificial) lighting systems that have the ability to generate specific and tunable wavelengths to generate plant growth and development. The baseline and measure horticultural lighting systems shall provide a comparable level of service and the energy use of the baseline solution must be adjusted to provide a comparable service as the Energy Efficiency measures. This Project will pursue Lab and Field demonstrations using the "Southern California Edison Indoor Horticulture Measure Eligibility and Calculations Methodology to quantify indoor horticultural lighting energy savings opportunities".	2018	2023
ET18SCE7050	ET18SCE7050 - Process Optimization of Controlled Environment Agriculture/Horticulture for Food Production Facilities	Active	2018	SCE research has been to pursue various research and technology assessments to garner insight on EE opportunities and the reduction of potential GRID impacts related to the growing markets of Indoor Horticulture/Agriculture.	2018	2023
ET18SCE7040	ET18SCE7040 - Remote Pump Monitoring (RPM Project - An Enhanced Retro-commissioning Project for Pumps)	Active	2018	Water-Energy efficiency to identify opportunities in pumping technologies & system(s) optimization and reliability.	2018	2022
ET18SCE7020	ET18SCE7020 - Rapid Energy Model Development for Residential Energy Simulation	Complete	2018	This is a web-based, energy efficiency recommendation engine providing a customized "path to zero-net energy" for any existing home. Homeowners can use this technology to quickly check which energy efficiency options make most sense for their individual homes, to reduce their energy use and move them closer to the goal of a zero-net energy (ZNE) home. This tool uses current technologies in building energy simulation and combines it in a novel way with other recent developments in 3D building data from aerial photography and cloud computing, to develop individual 'energy models' of each home. The process is fully automated and repeatable, to allow generation of energy models at a massive scale, from individual homes to neighborhoods and cities. Generating data at this scale provides a unique insight into energy efficiency opportunities in the existing homes sector.	2018	2020

SCE Energy Efficiency Projects 2018-2022

Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET18SCE7010	ET18SCE7010 - Insulating Stucco	Complete	2018	Utilizing insulating stucco will result in reduction in energy usage and leakage in homes	2018	2018
ET18SCE1161	ET18SCE1161 - Understanding and Optimizing Advanced Refrigeration Systems - CTS	Active	2018	The commercial and industrial refrigeration landscape is changing due to pressures to reduce global warming potential (GWP) and ozone depletion potential (ODP) of refrigerants. In response to these changes, manufacturers are producing new technologies which are designed to accommodate the required changes, and provide equivalent or improved efficiency, capacity and overall performance. Ammonia is a well-established and efficient refrigerant which has limitations in the form of mild toxicity and flammability. This project seeks to perform laboratory evaluations of several new packaged refrigeration systems to understand their performance and viability in refrigerated warehouse and walk-in cooling applications.	2018	2022
ET18SCE1151	ET18SCE1151 - Ultra Low Charge NH3 Packaged Refrigeration Technology Field Optimization	Active	2018	To demonstrate and assess improved energy efficiency with continuous performance monitoring, flexible demand response and certified ADR capabilities for both low and high temp refrigeration. Project will utilize an ultra-low charge, zero GWP, flexible tonnage packaged system, continuous monitoring and advanced control strategies to enable Flexible DR Unit is more energy efficient than incumbent technology. Provide ongoing comprehensive real-time monitoring of all metrics to build a calibrated calculation tool to support further market adoption and/or program. Besides EE, there is an opportunity for Flexible Demand Response in various refrigeration control applications and this project will determine the best site control strategies to demonstrate DR. It is expected to achieve least 20% demand reduction by taking advantage of built-in inherent storage capabilities based on the thermal mass of frozen or refrigerated food—that allows to temporarily shed, shift or adjustment in power demand, key enablers for fast and flexible demand response. Additionally electric defrost control can also help add load to ameliorate renewable grid effects. Demonstrate and report on air quality and any water savings benefits achievable from use of the technology. This technology can replace all GWP and ODP refrigerants with an energy efficient and DR ready	2019	2022
ET18SCE1120	ET18SCE1120 - High Performance Conveyorized Toaster	Complete	2018	High performance conveyorized toaster used by fast food restaurants especially. Predicted performance is to reduced energy for toasting buns and english muffins is 2/3 of incumbent technology. Market study, baseline performance and field testing of the high performance units.	2018	2020
ET18SCE1110	ET18SCE1110 - Dairy Cooling Fan Controller Project	Complete	2018	This solar control system is a load shifting technology that shifts power loads for A/C motors back and forth between solar PV panels during the day-time hours and the power-grid during the night-time. Evaluate the effectiveness and efficiency of a new proprietary solar control technology to determine the overall performance of the technology. The objective will be to compare energy usage between the solar control technology and a baseline system consisting of conventional dairy barn fans.	2018	2020
ET18SCE1100	ET18SCE1100 - Cloud-based software for operational energy efficiency savings in commercial buildings	Complete	2018	The Energy Management Software automates tenant billing, energy reporting, and their analytics have been shown to reduce costs by up to 10%. Validate the use of this Energy Management Software to improve building energy use. A field study will be implemented along with a group of control sites. Internal billing study will be conducted and compared.	2018	2021
ET18SCE1090	ET18SCE1090 - Demonstration of ZNE Technologies in a Dormitory Environment	Complete	2018	A primary goal of this project is to demonstrate the technical and economic feasibility of the advanced measures for all-electric ZNE dormitory style housing. A secondary objective is to study how the all-electric ZNE residential buildings performs using the all-electrical technologies.	2018	2022
ET18SCE1070	ET18SCE1070 - Variable Speed - Fixed Displacement Hydraulic Pump Unit with Smart Controller Assessment	Complete	2018	Variable Speed Drives with Smart Controllers for Hydraulic Power units for metal working machines. Project will look at energy savings for this system compared to fixed speed unit as prime mover.	2018	2018

SCE Energy Efficiency Projects 2018-2022

Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
ET18SCE1060	ET18SCE1060 - Add-on Adiabatic Pre-cooling for Refrigeration Assessment	Complete	2018	Product would be considered retrofit add on (REA). It is an evaporative pre-cooler for air cooled condensers of commercial/industrial refrigeration systems. By using this pre-cooler, the dry bulb temperature of the air entering the condenser is cooler by some amount related to the evaporative effectiveness; as a result, the compressor efficiency is improved.	2017	2019
ET18SCE1040	ET18SCE1040 - Hybrid Ventilation Fan	Complete	2018	Compare this hybrid exhaust fan airflow and power consumption to other products in the exhaust fan category. A test apparatus will be built to test powered exhaust fans delivering required airflow and static. The fan will also be installed in the field to determine a "real world" performance and application of the hybrid fan. A test apparatus will be built to test powered exhaust fans delivering.	2018	2021
ET18SCE1020	ET18SCE1020 - LBNL - FLEXLAB Study of Connected Tunable White LED	Complete	2018	This project evaluated tunable white LED fixtures (troffers and pendants) with integrated controls, including daylight dimming, to determine visual and circadian performance and energy usage in commercial office space. The analysis culminated in information/recommendations for connected, tunable systems and strategies that optimize visual lighting performance, circadian stimulus, and EE.	2018	2021
ET18SCE1010	ET18SCE1010 - CLTC - ALCS Bench Testing - System Self Energy Metering	Complete	2018	Advanced Lighting Control System Bench Testing: The evaluation will assist the implementation of a metering-on-board utility program that will enable utilities to ‘pay for performance’. When validated systems are used as part of a utility-incentivized lighting retrofit or new construction project, the systems on-board metering and reporting features may be used to quantify the actual energy use of the system and earn incentives, as opposed to the current, expensive practice of third-party verification.	2018	2022

SCE Demand Response Projects 2018-2022

Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
DR22.02	DR22.02 - LOC-GFO-19-301-4 HP-flex: Next Generation Heat Pump Load Flexibility DR	Active	2022	Southern California Edison (SCE) provided a Letter of Commitment in support of LBNL's proposal for the EPIC GFO 19-301 Group 4 EPIC solicitation. The project will develop and demonstrate an open-source energy and load management system designed to control advanced heat pumps on small/medium commercial buildings.	2019	2024
DR22.01	DR22.01 - LOC DOE FOA-0002090, "A framework to characterize the performance of building components in providing flexible loads and building services using a hardware in- the-loop approach" - DR	Active	2022	SCE provided a Letter of Commitment (LOC) in support of LBNL's proposal titled "A framework to characterize the performance of building components in providing flexible loads and building services using a hardware-in-the-loop approach" in response to the DOE's BENEFIT FOA 0002090 solicitation. This DOE project will generate high fidelity measurements of building system energy use and their ability and performance to provide grid services and demand flexibility while maintaining acceptable levels of service to building occupants.	2019	2023
DR21.03	DR21.03 - Dynamic Rate Pilot	Active	2021	The Pilot will combine real time pricing design and transactional subscription elements from both the RATES and UNIDE tariff concepts and will investigate how customer- based distributed energy resources can act as both flexible assets and grid interactive resources when these new pricing signals are transmitted to end use customers as proposed in the UNIDE model.	2021	2024
DR21.01	DR21.01 - DR-TTC Dynamic HVAC Test Chamber	Active	2021	TTC seeks to build a test chamber capable of advanced dynamic HVAC testing at the facility in Irwindale, CA and this will provide capabilites for assessing demand response potential of appliances and systems for future demand response programs.	2021	2022
DR20.03	DR20.03 - Demand Response Technology Enhancements	Active	2020	The objective of this project is to study the value and assess the gaps in dynamic pricing based ADR. This objective is approached by evaluating the tariffs and their characteristics, how these tariffs can be communicated to different customers using different communication technologies and the impact of the emerging trends (such as IoT, energy storage systems, etc.) in improving the ADR.	2020	2022
DR20.02	DR20.02 - Wedgewood Demand Response and Flex Demonstration	Complete	2020	Demand management and flexibility test of a commercial building with implemented EE and DR measures	2020	2021
DR20.01	DR20.01 - C&S CTA-2045 Test Procedure & ENERGY STAR Specifications	Complete	2020	Codes and Standards will work with ENERGY STAR on two aspects: 1) update the test methods for "connected water heaters" and ENERGY STAR "specifications."	2020	2020
DR19.11	DR19.11 - LOC-GFO-19-301-4 Optimizing heat pump load flexibility for cost, comfort, and carbon emissions (DR)	Active	2019	Develop, test and demonstrate an open-source, add-on, advanced heat pump load control system for both water heating and space conditioning that does all of the following: 1. Responds to hourly or sub-hourly price and demand response signals to minimize cost and grid impacts 2. Optimizes energy use based on marginal GHG emission data 3. Optimizes energy use based on building owner/occupant preferences, and 4. Provides reliable and cost-effective load flexibility as a grid resource.	2021	2023
DR19.10	DR19.10 - Market Assessment of Water & Wastewater Treatment Load Management Strategies in California	Complete	2019	This study builds on SCE's recent research and analyses on the subject that looks beyond the largest agencies and common strategies to assess technical DR opportunities, strategies, and program offerings that can be useful to a broader set of agency sizes and treatment plant configurations. Accompanying this report is the DR Matrix, a technical decision support tool that describes twenty-five discrete DR measures that are evaluated in terms of potential, risk, technical difficulty.	2019	2020
DR19.08	DR19.08 - Grid Responsive Heat Pump Water Heater Study	Active	2019	As part of SJV Pilot, SCE included a study to deploy HPWHs equipped with communication technology that will allow the water heater to be used as a grid-responsive heating technology element of the pilot to electrify homes and reduce emissions within the SJV. This study will only be conducted in 12 residential single-familydwellings of customers participating in the SJV Pilots.	2019	2024
DR19.07	DR19.07 - Measuring Builders Installed Electrical Loads	Active	2019	The aim of this sub-project is to collect data on electricity consumed by equipment in newly-constructed homes that are either required by health and safety codes or are considered necessary to make the house attractive to buyers. This aspect of residential energy use has not been studied but anecdotal measurements from an ongoing EPIC project suggest that builder-installed loads are responsible for as much as 1300 kWh/year before occupants have moved in.	2019	2022

SCE Demand Response Projects 2018-2022

Project Number	Project Name	Status	Project Funding Year	Description	Project Start	Project End
DR19.05	DR19.05 - Virtual Power Plant (VPP) Project	Active	2019	The VPP project will enroll 200-500 customers in the project from a population of approximately 1,000 customers with existing or new Sunrun PV-paired battery systems. This project provided M&V funding to assess the projects load impacts.	2019	2022
DR19.04	DR19.04 - DR Evaluation of Direct Energy Savings and Demand Response Potential from PCM for Cold Storage Applications	Complete	2019	This project will help determine the the demand response potential of Phase Change Materials (PCMs) in cold storage applications at Low Temperature -10 - 0 F (-23 - 18 C) to reduce electric loads in cold storage applications during critical peak load conditions.	2019	2021
DR19.03	DR19.03 - Smart Speakers	Active	2019	This project's goals are to test optimization of connected thermostats and other loads via voice commands based on TOU rate peak times and customer preferences. Voice interactions related to energy (usage, estimated bills, best times to use appliances, etc.) will undergo evaluation to determine most common and additional desired interactions. The system will use meter based home-by-home M&V methodology to understand energy usage impacts and potentially develop a deemed measure.	2019	2022
DR19.02	DR19.02 - Low Income Multi-Family Battery Storage, Solar PV and Data Collection - Mosaic	Complete	2019	The project will review battery energy storage systems so SCE can provide better customer support, improved grid infrastructure design, and gain higher Customer Satisfaction scores from these customers. The documented results will identify the technology and interface benefits and gaps within this emerging market and necessary technology advancements.	2019	2022
DR18.13	DR18.13 - D1- "New Residential Demand Response Opportunities in SCE Service Territory"	Complete	2018	SCE has identified important changes in the energy environment that with both make residential DR more critical and may change how residential DR operates. Each of these key changes implies a need to better understand the residential DR enabling technology emerging markets and to identify optimal ways to enhance residential DR customer engagement though communication and coordination	2018	2021
DR18.12	DR18.12 - D2 – Residential Communication Protocols	Complete	2018	The Project will be examining communications strategies for "connected" residential electrical end uses for their ability to be harmonized with SCE Grid Mod technologies such as IEEE 2030.5 (SEP2)and DNP3 (IEEE 1815). This project will review architecture and use cases of OpenADR 2.0B (IEC 62746-10-1) as a parallel secure platform as well as ANSI CTA-2045 and ISO/IEC 15116 V2G. Coordinated by the EPRI cyber team	2018	2021
DR18.11	DR18.11 - Automated Demand Response Capabilities of Variable Refrigerant Flow Technologies: Manufacturer Outreach	Complete	2018	Automated Demand Response Capabilities of Variable Refrigerant Flow Technologies: Manufacturer Outreach	2019	2019
DR18.10	DR18.10 - Automated Demand Response-Enabled Solution Development and Deployment for HVAC Distributors	Complete	2018	Automated Demand Response-Enabled Solution Development and Deployment for HVAC Distributors	2019	2021
DR18.09	DR18.09 - Flexible DR integration	Active	2018	Flexible DR opportunities with GRID integrated water technologies and systems	2019	2022
DR18.06	DR18.06 - Willowbrook-Integration to Enable Solar as a Distribution Resource	Complete	2018	Willowbrook Low-Income Multi-Family DER: Energy Storage with PV Study.	2019	2022
DR18.05	DR18.05 - Residential Energy Storage Study	Complete	2018	Retail Automated Transactive Energy Systems (BESS & PV) Project	2019	2022
DR18.04	DR18.04 - Heat Pump Water Heater Systems Lab	Complete	2018	HPWH Flexible DR Communication Demonstration Lab for Water Heating System	2019	2022
DR18.03	DR18.03 - Connected Pool Pump Market Assessment	Complete	2018	Flexible DR for Connected Pool Pump Market Assessment	2019	2020